14278

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Popular Electronics®

WORLD'S LARGEST-SELLING ELECTRONICS MAGAZINE AUGUST 1976/$1

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TEST REPORTS

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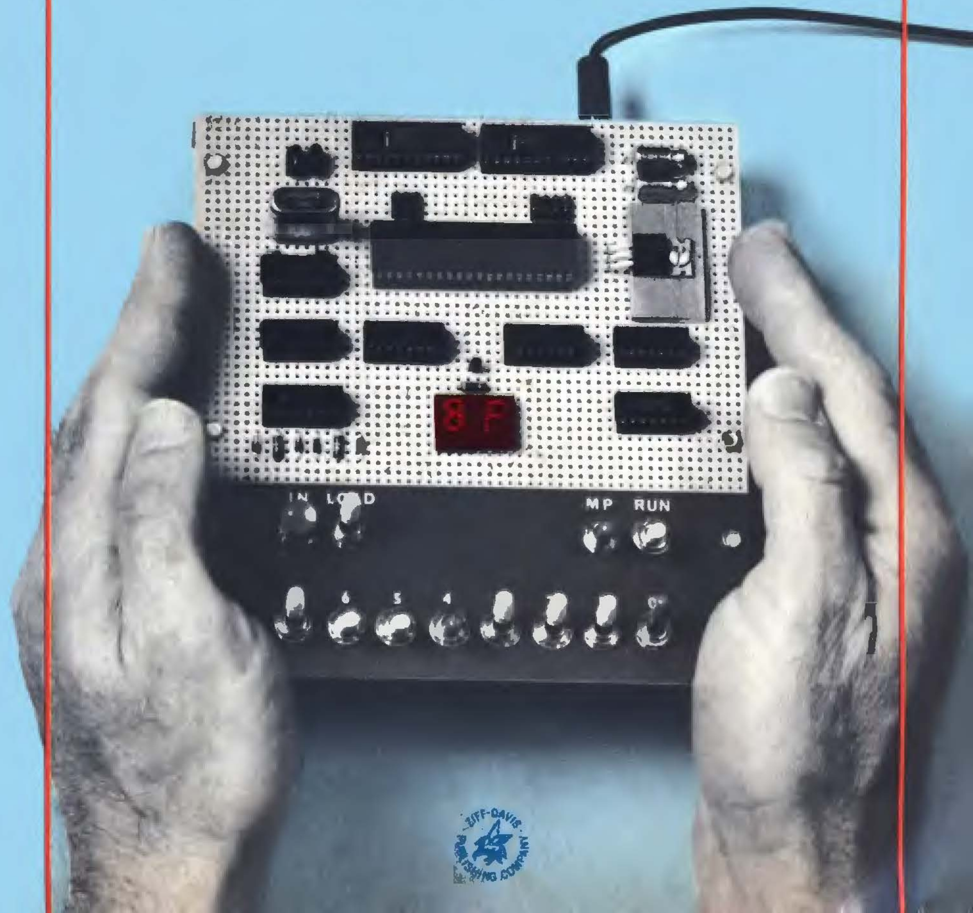
THE COSMAC 'ELF'

A MICROCOMPUTER TRAINER THAT'S POWERFUL, EXPANDABLE AND COSTS AS LITTLE AS $80.



Experience is the best teacher. You might settle for any CB first time around. Understandably. A lot of people think they're all pretty much alike. But you'll soon discover that, like everything else, there are exceptions.

Ask the pros. America's long distance truckers. These guys talk CB day in and day out. And they demand the best. That's why truckers refer to the Cobra 29 as "The Diesel Mobile."

Listen to Cobra. You'll hear a big difference. Because the Cobra 29 gives you features which assure crystal clear reception. Like switchable noise limiting and blanking, to cut out practically all pulse and ignition interference. Add squelch control and RF gain and you've got exceptional—adjustable—receiver clarity. Even in the heaviest CB traffic. You also get Delta Tuning which makes up for the other guy, because even off-frequency transmitters are pulled in. Perfectly.

Talk to Cobra. And you know you're punching through. One glance at the 29's over-sized illuminated meter tells you just how much power you're punching out and pulling in. For voice modulation the DynaMike delivers at 100%. Same way with power: The 29 transmits at maximum power levels.

Sooner or later you'll get a Cobra. And you'll get engineering and craftsmanship second to none. Performance that will make your first CB seem obsolete. Reliability and durability that have set standards for the industry. Above all, you'll get power. The power to punch through loud and clear like nothing else. Because when it comes to CB radio, nothing punches through loud and clear like a Cobra.

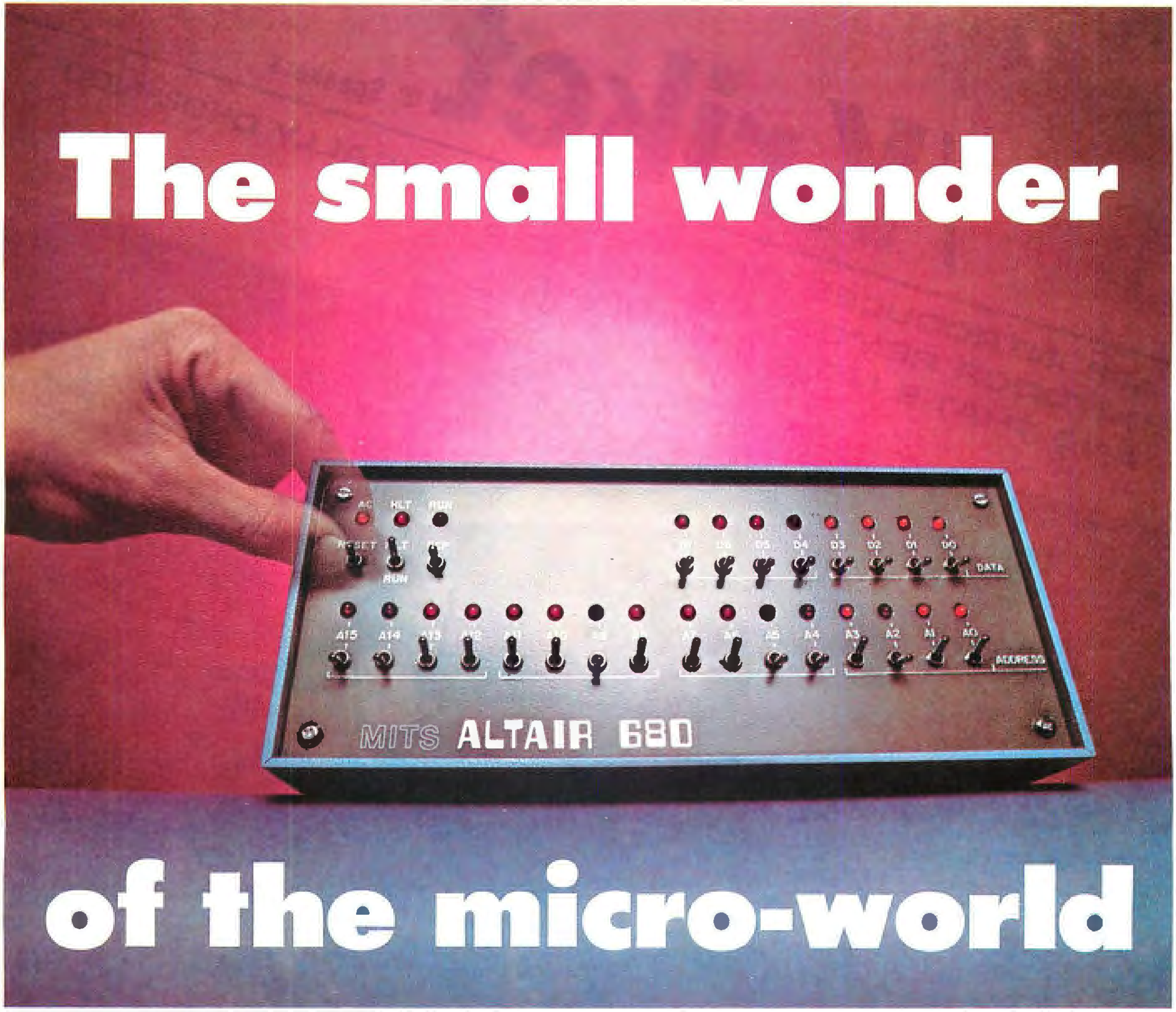
Cobra

Punches through loud and clear.

Cobra Communications, Products of Dynascan Corp.
1801 W. Belle Plaine, Chicago, Illinois 60613

CIRCLE NO. 14 ON FREE INFORMATION CARD

IF YOUR FIRST CB ISN'T A COBRA YOUR SECOND ONE WILL BE.



Measuring just 11" wide x 11" deep x 5" high, and weighing a mere 7 pounds, the Altair ™ 680b is a complete, general-purpose computer.

The secret to this revolutionary, small computer is its CPU board. This double-sided board fits along the bottom of the Altair case and plugs directly into the front panel board. It contains the new 6800 microprocessor, 1,024 bytes of RAM memory, a 256 byte PROM monitor, provisions for 768 bytes of additional PROM or ROM, and a single Interface port with a Motorola ACIA serial interface adapter which can be configured either RS-232 or TTY. A five level Baudot interface option is also available.

The Altair 680b can be programmed from front panel switches, or it can be interfaced to a video display terminal, or teletypewriter. Three additional circuit boards can be plugged inside the Altair 680b for further memory and interface expansion. The first of these boards is a 16K static RAM memory board.

Software already developed includes Altair 680 BASIC with all the features of the 8K BASIC previously developed for the Altair 8800. These include Boolean operators, the ability to read or write a byte from any I/O port or memory location, multiple statements per line, and the ability to interrupt program execution and then continue after the examination of variable values. This software takes only 6.8K bytes of memory space and a copy is **included free with the purchase of the Altair 680 16K memory board.**

Other software includes a resident two pass assembler. The Altair 680b is also compatible with Motorola 6800 software.

The Altair 680b is ideal for hobbyists who want a powerful computer system at an economic price. Altair 680b owners qualify for membership in the Altair Users Group, and like other Altair owners, they receive a complimentary subscription to **Computer Notes** and complete factory support.

PRICES:

Altair 680b kit with complete, easy-to-understand assembly manual, operator's manual, and programming manual	$466
Assembled Altair 680b	$625
Altair 680b Turnkey model kit	395
Expander Card 680MB (required to expand 680)	$ 24
Altair 680BSM 16K static RAM board kit with 680 BASIC	$685
Altair 680 BASIC when purchased separately	$200
Baudôt option	$ 42

MAIL THIS COUPON TODAY

☐ Enclosed is a check for $________
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☐ Altair 680b ☐ Kit ☐ Assembled ☐ *Other* (specify)
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AUGUST 1976 VOLUME 10, NUMBER 2

Popular Electronics®

WORLD'S LARGEST SELLING ELECTRONICS MAGAZINE

FEATURE ARTICLES

CONSTRUCTION ARTICLES

COLUMNS

PRODUCT TEST REPORTS

DEPARTMENTS

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Editorial

PLANTING ELECTRONICS HOBBY SEEDS

A hobby is generally described as a pursuit of an interest outside one's regular occupation. In electronics, however, many hobbyists are on a busman's holiday. For example, a recent study revealed that over 44% of PE readers view electronics as both a career and a hobby, while an additional 13% note that they pursue the hobby because they're either employed in electronics or in an area where electronics knowledge is valuable.

Other interesting PE-reader demographics include: 14.4% have taken post-graduate work, which is included in 65.7% that are attending, have attended or have graduated from college. At the other end of the spectrum, 8.2% are under 18 years old and a total of 16.8% are students. Play these figures against almost 400,000 paid circulation and you'll appreciate the depth and diversity of our readership.

Most hobbyists try to get as much as they can out of their avocations. But electronics hobbyists are among the few that have the chance to give, which can be equally rewarding. For our readers attuned to education, and fortunate to have a hobby that can be shared, there is an excellent opportunity to personally plant the seeds for what might become a lifelong, fulfilling hobby for many people.

For example, a growing number of electronics enthusiasts take the time to teach youngsters about electronics—from how to get a Novice license to wiring a kit. Where can the newcomers be reached? Try churches, synagogues, local Parent-Teacher-Student Associations (PTSA's), Boy Scouts, fraternal organizations, and the neighborhood children for starters. One of our editors, for instance, has a string of neighborhood boys and girls who visit him (and his home computer) regularly. Interestingly, his is the only undamaged property in the area when Halloween ends.

Other electronics hobbyists visit veterans' hospitals to introduce them to electronics so that the patients can fill their otherwise boring days with meaningful efforts. And the hobbyists follow up with other visits to provide continuing guidance.

Some experienced electronics buffs work with local schools to refine science, math and vocational curricula, to develop programs for gifted children, etc. They've discovered that ivory-tower curricula specialists rarely know "where it's at," unfortunately, and too often develop "busy work" for advanced students, the equivalent of a fancy way to shoe a horse or some other useless pursuit.

In contrast, some of our readers have set up microcomputer training programs to introduce youngsters to computer science, binary, hexadecimal and octal arithmetic, all at little cost. Moreover, it has been proved that it's as easy to learn about computers as it is to learn multiplication. It's a lot more fun, too. Others have arranged for student trips to their homes to see how a radio amateur operates his rig, how a home microcomputer can perform astounding feats in print and video, and how to make professional-type tape recordings.

So the next time you're wondering about which sub-par TV program to watch, why not give some thought to the art of giving. You've got the knowledge, the experience, and a stimulating hobby in your corner.

Art Salsberg

SBE OPTI/SCAN.

The scanner that's only a light beam away from 16,000 frequencies.

OPTI SCAN is, without question, the world's most advanced scanning receiver. It is the only crystal-less scanner that optically scans any station in the nation by the use of programmed cards with permanent memory. Simply program and insert the card, OPTI/SCAN does the rest. You can change cards even while driving without ta[illegible] your eyes off the road. Built-in AC/DC operation.

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CIRCLE NO. 54 ON FREE INFORMATION CARD

Letters

IN REBUTTAL

In rebuttal to A.D. Acton's comment in the April 1976 Letters Column, I for one appreciate having a source from which to buy parts and kits listed at the ends of parts lists for POPULAR ELECTRONICS construction articles. I live in an area of the country where obtaining many parts is almost impossible. Without a parts or kit supplier, I would have to forego building many of the PE construction projects that appeal to me.
—*Glenn A. Goss, Elon College, N.C.*

SWL SPACE INVADERS

I am very disturbed with the "DX Listening" column. As I'm sure you are aware, the 40-meter Amateur Radio band covers the frequency range of 7.0 to 7.3 MHz. Most countries acknowledge these frequencies as belonging to hams and do not broadcast on them. Several communist countries, however, insist on transmitting on several frequencies in the 40-meter band, causing considerable interference to the hams, who have legal ownership of this band.

I feel that your printing of frequencies of these illegal broadcasts aids and abets the invasion of the 40-meter band. I hope, therefore, that in the future you will delete any listing of international broadcasts on amateur frequencies.—*Onis Cogburn, K5VKQ, College Station, TX.*

The 7.0-to-7.1-MHz segment of the 40-meter band is allocated to Amateur Radio on a world-wide basis (to 7.3 MHz in Region II). In Regions I (Eurasia & Africa) and III (China, India, Iran, and Australasia), the 7.1-to-7.3-MHz portion is allocated to Broadcasting by the ITU. Many noncommunist countries use the "41-meter" band.

WHERE'S MY CB LICENSE?

After five months, I still haven't received my license. I am frantic because I can't use my CB rig without a license for fear of being caught. As a result, I'm on the verge of selling my rig.
—*Roger L. Triplett, Louisburg, WV.*

As mentioned in last month's CB Scene, there's a new temporary permit that can put you on the air legally without delay. The form to be filled out was also printed last month. However, the address to which Form 505 is to be sent (Item 2, p 98) is simply: Federal Communications Commission, Gettysburg, PA 17326.

Out of Tune

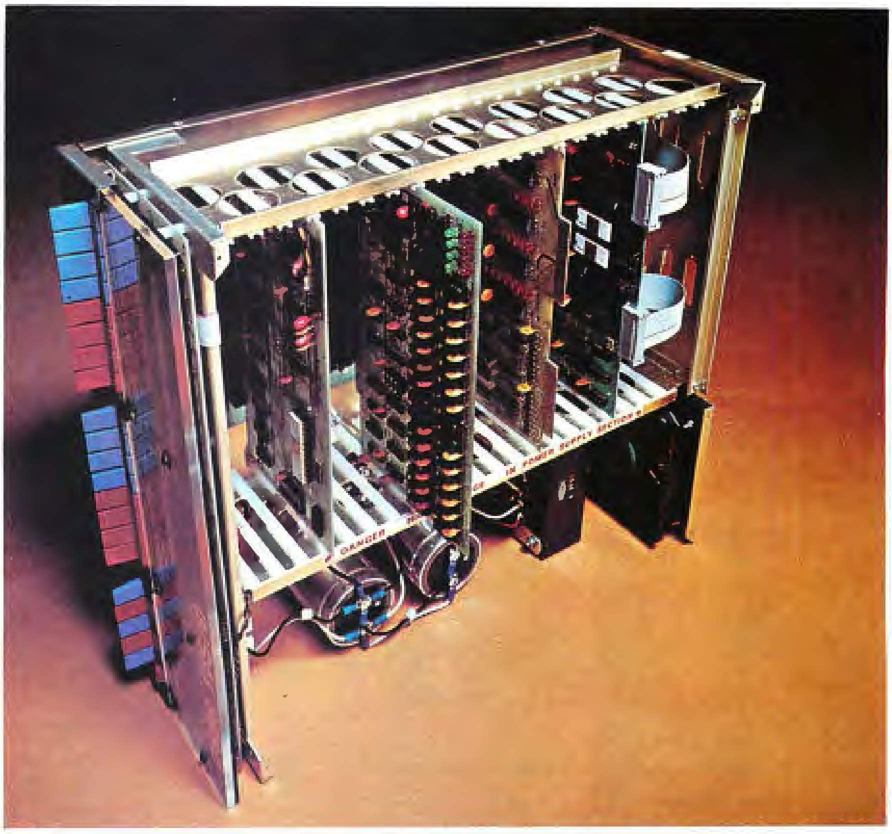
In "Now You Can Build a Scientific Programmable Calculator" (May 1976), there is an error in the program for solving $x - 3 =$ on page 38. Steps 12, 13, and 14 (GO TO,2, and 0) will cause the machine to subtract 11 from x instead of 1. It will also cause the program to "not count" the number of times it goes through a loop, and the ultimate answer to any x with this program will be 0. The proper instructions should be GO TO, 1, and 8, respectively.

In "Space War Game" (April 1976), type numbers were inadvertently omitted in the Parts List for *IC7* through *IC10*. Integrated circuits *IC7* and *IC8* are 4023's, *IC9* and *IC10* 4001's.

In "Tips and Techniques," June, 1976, the circuit for Alan Kong's tip is incorrect. To add a tail to a seven-segment "9", the bottom resistor should be connected to the "g" segment output, not the "d" segment output. The other input is correctly shown connected to the "a" segment output, and the collector of the top transistor is properly connected to the "d" segment driver. The circuit for adding a top tail to a seven-segment "6" is correct.

If you thought a rugged, professional yet affordable computer didn't exist,

think IMSAI 8080.



Sure there are other commercial, high-quality computers that can perform like the 8080. But their prices are 5 times as high. There is a rugged, reliable, industrial computer, with high commercial-type performance. And prices that are competitive with Altair's hobbyist kit. The IMSAI 8080. Fully assembled, it's $931. Unassembled, it's $599. And ours is available now.

In our case, you can tell a computer by its cabinet. The IMSAI 8080 is made for commercial users. And it looks it. Inside and out! The cabinet is attractive, heavy-gauge aluminum. The heavy-duty lucite front panel has an extra 8 program controlled LED's. It plugs directly into the Mother Board without a wire harness. And rugged commercial grade paddle switches that are backed up by reliable debouncing circuits. But higher aesthetics on the outside is only the beginning. The guts of the IMSAI 8080 is where its true beauty lies.

The 8080 is optionally expandable to a substantial system with 22 card slots in a single printed circuit board. And the durable card cage is made of commercial-grade anodized aluminum. The Altair kit only provides 16 slots maximum in four separate sections, each section requiring 200 solder connections.

The IMSAI 8080 power supply produces a true 28 amp current, enough to power a full system. The Altair produces only 8 amps.

You can expand to a powerful system with 64K of memory, plus a floppy disk controller, with its own on board 8080–and a DOS. An audio tape cassette input device, a printer, plus a video terminal and a teleprinter. These peripherals will function with an 8-level priority interrupt system. IMSAI BASIC software is available in 4K,

that you can get in PROM. And a new $139 4K RAM board with software memory protect.

Find out more about the computer you thought didn't exist. Get a complete illustrated brochure describing the IMSAI 8080, options, peripherals, software, prices and specifications. Send one dollar to cover handling.

Call us for the name of the IMSAI dealer nearest you.

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New Products

Additional information on new products covered in this section is available from the manufacturers. Either circle the item's code number on the Reader Service Card inside the back cover or write to the manufacturer at the address given.

SWR/FIELD-STRENGTH METER

Siltronic's Model SWR-3DX SWR power and field strength meter permits direct reading of SWR from 1:1 to 3:1 with an accuracy of 5%. The unit has two r-f power scales, reading from 0 to 20 watts and 0 to 200 watts with 10% accuracy. Includes antenna for field-strength measurements. Frequency range is 3.5 to 55 MHz. $27.95.

CIRCLE NO. 84 ON FREE INFORMATION CARD

THORNTON DUAL-TRACE OSCILLOSCOPE

Thornton's Model 4D-10 portable solid-state oscilloscope features a 10-MHz bandwidth and dual-trace capability. Built in is a trace finder circuit that speeds searching for a lost trace. A single control is used for trigger level and polarity. Sensitivity is independently adjustable for the

two input channels over a range of from 10 mV/cm to 50 V/cm in 12 calibrated ranges. A wide selection of sweep speeds (1 µs/cm to 100 ms/cm in 16 ranges) is backed up by a ×5 magnifier. Display size is 8 × 6 cm. Display modes include A-only alternate and chopped. Input impedance is 1 megohm, which can be increased to 10 megohms with an optional probe. $445.

CIRCLE NO. 85 ON FREE INFORMATION CARD

EMPIRE MANUAL RECORD PLAYER

Empire's new Model 698 manual record playing system features a newly designed tonearm, while retaining the belt-drive and anti-acoustic feedback system used in an earlier unit. The low-mass tonearm has a rear counterweight that is decoupled through a special rubber compound suspension and a new removable cartridge shell. Touch-sensitive controls actuate the cueing system through a damped solenoid that is said to accurately raise and lower the stylus in the same groove every time. A photocell is used to electronically trigger the tonearm to lift at the end of record play. The units' antiskating device applies a diminishing force as the tonarm moves closer to the center of the record.

CIRCLE NO. 86 ON FREE INFORMATION CARD

NEW-TRONICS BASE STATION CB ANTENNA

In line with changes in FCC Rules permitting greater antenna heights, New-Tronics Corp. has announced availability of the Hustler Model 27-TD "Super Swamper" base station CB antenna. The antenna's design is based on the 0.64-wavelength principle used in commercial broadcasting to obtain optimum low-angle signal radiation. In CB, the 0.64-wavelength, 22 (6.7-m) radiating element of the Super Swamper is said to substantially improve performance to extend AM and SSB two-way omnidirectional radio communications over greater distances. Additionally, the antenna has extremely low SWR. $52.95.

CIRCLE NO. 87 ON FREE INFORMATION CARD

MICRO GENERAL CHESS COMPUTER

Micro General Corp. has announced the introduction of the "Micro-80" chess computer that keeps exact time and move count for the most popular variations of time-controlled chess after being programmed. The computer keeps track of the type of game being played, as well as time and moves. The crystal-controlled timer always displays the time remaining to each player down to the second as well as the number of moves yet to be played. It also automatically adds unused thinking time to each player's "time bank" when applicable. A beeper in the lock provides warnings and end-of-game signals. The clock features STOP, CONTINUE, and RESET functions, a low battery power level indicator, and display blanking for power conservation. $245.

CIRCLE NO. 88 ON FREE INFORMATION CARD

ADVENT BOOKSHELF SPEAKER SYSTEM

The Advent/3 is a two-way acoustic-suspension speaker system housed in a walnut-grained, vinyl-clad cabinet that measures 16" × 10" × 6½" (49.6 × 25.4 × 16.5 cm). The 8-ohm system requires a minimum of 10 watts of driving power. Its frequency range is essentially the same as that of the original Advent loudspeaker, with the exception of the lowest half-octave of bass. Price is $50.

CIRCLE NO. 89 ON FREE INFORMATION CARD

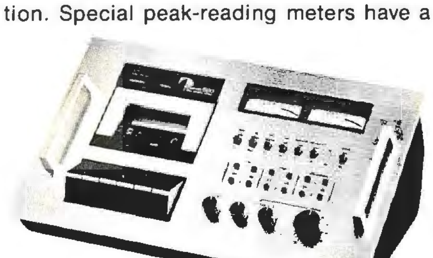
ZODIAC CB SERVICE MONITOR

The Swiss-made Model U-2 is a CB service instrument from Zodiac Communications Corp. It uses a frequency synthesizer for testing by CB equipment manufacturers and field service technicians. The portable instrument is powered by its own 12-volt battery. On the bench, it can be powered by an external 12-volt dc source. The instrument features a r-f signal generator, wattmeter, SWR meter, and field-strength meter. It generates 210 frequencies at 5-kHz intervals within the 26.49-to-30.11-MHz range, including all existing and proposed CB channel frequencies. It can also be used to measure sensitivity at the carrier frequency, passband in kilohertz, and adjacent-channel selectivity. Power output up to 5 watts, modulation up to 100%, and SWR up to 3:1 can also be measured.

CIRCLE NO. 91 ON FREE INFORMATION CARD

NAKAMICHI CASSETTE DECK

Nakamichi's Model 600 cassette "console" features a record-playback head. It's said to provide a frequency response of 40 to 18,000 Hz ± 3 dB. (The signal-to-noise ratio is rated at better than 68 dB.) "Intermodulation Suppressor" circuitry makes possible a distortion of 0.5% at 0 dB and increases dynamic range to permit recording at levels up to +7 dB at reference 3% distortion. Special peak-reading meters have a



47-dB range. A pulse-controlled dc servo motor is used. Also included are: built-in Dolby noise reduction, 400-Hz calibration tone, MPX filter for FM recording, memory rewind and equalization switches.

CIRCLE NO. 92 ON FREE INFORMATION CARD

PIONEER AM/STEREO FM RECEIVER

Pioneer's Model SX-1250 AM/stereo FM

receiver is rated at 160 watts/channel (rms) into 8 ohms from 20 to 20,000 Hz at 0.1% or less THD. It has twin stepped tone controls for bass and treble adjustments, step-type volume control calibrated in decibels, two tape monitor circuits, pushbutton function selection with illuminated readout, separate access to preamplifier and power amplifier, five-gang tuning capacitor and dual MOSFET's in the FM front end, phase-locked loop IC for stereo FM decoding, and 25-μs deemphasis switch for Dolby-encoded FM broadcasts. Among the more important specifications are: 1.5 μV IHF usable sensitivity in mono (2.9 μV in stereo); 80 dB mono, 74 dB stereo S/N; 11.5 (mono) and 36 dBf (stereo) for 50-dB quieting sensitivity; typically 0.3% maximum FM distortion; 83 dB alternate-channel selectivity; 35 dB stereo (FM) separation, 30 to 15,000 Hz; 110 dB image and spurious rejection; 120 dB i-f rejection.

CIRCLE NO. 93 ON FREE INFORMATION CARD

TRIPLETT HIGH-ACCURACY MULTIMETR

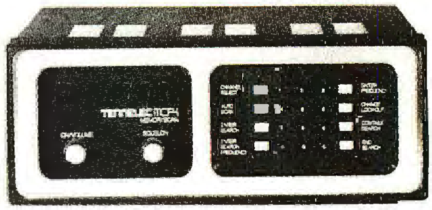
The Model 60-NA from Triplett Corp. is a portable precision VOM that features a large easy-to-read 4½" (11.4-cm) anti-parallax mirrored scale. It has a dc accuracy of ±1.5% full-scale (±3% on ac), plus a multiplier switch that permits more read-

ings to be taken at the upper portion of the scale for greater accuracy. Fifty separate ranges provide measurement capacity of up to 1000 volts ac and dc, 1000 mA dc current, up to ×100K ohms, and from −20 to +52 dB. Ac current up to 300 amperes can be measured when the VOM is used with the optional Model 10-C adaptor. Three fuses are used in the meter to provide burn-out-proof protection and for user safety. $130.

CIRCLE NO. 94 ON FREE INFORMATION CARD

SCANNER USES MICROPROCESSOR

The Tennelec Model MCP-1 is said to be the first scanning receiver to use a computer-like microprocessor that lets the user tune in as many as 16,000 low- and high-vhf and uhf band frequencies. Sixteen different frequencies can be stored in memory through a calculator-like keyboard. The microcomputer system operates without channel crystals. Super-



selective dual filters reduce station overlap for maximum radio reception. The receiver's search mode can be set to go through 256 channels in 5-kHz increments at 10 channels/second. Channels can be quickly entered into memory or changed by pressing the appropriate keys. The scanner has a six-digit, 7-segment LED frequency display.

CIRCLE NO. 95 ON FREE INFORMATION CARD

ESS STEREO POWER AMPLIFIERS

The Model 500A is one of a new Eclipse series of stereo power amplifiers introduced by ESS, Inc. It is rated at 250 watts minimum continuous power per channel, both channels driven into an 8-ohm load with no more than 0.25% THD. Frequency response is said to be 20 to 20,000 Hz ±0.25 dB. Other specifications include: hum and noise, −102 dB; sensitivity, 0.75 volt; input impedance, 25,000 ohms. It has two 4½" VU meters with three sensitivity ranges, pushbutton twin stereo speaker system selection, and two viscous damped level controls. Measures 19" W × 13" D × 7½" H (48 × 33 × 19 cm) and weighs 49 lb (22 kg). $826.00. Address: ESS, Inc., 9613 Oates Dr., Sacramento, CA 95827.

CRAIG MOBILE AM CB TRANSCEIVER

Economy is the key feature of the Model 4101 mobile AM CB transceiver from Craig Corp. The transceiver has a crystal-synthesizer network that provides full 23-channel coverage. Built-in are automatic noise limiter (anl), voice compression, and adjustable-squelch circuits. A LED modulation indicator monitors transmissions, while an ON AIR legend lights up when in

the transmit mode. A crystal filter system guards against adjacent-channel interference, and automatic protection is provided for transistor overload. Included are an external-speaker jack and detachable microphone. The reversible mounting bracket allows mobile installation from top or bottom. $129.95.

CIRCLE NO. 97 ON FREE INFORMATION CARD

If you want an exciting future like this, it starts with an FCC license!

Get that license at home, the practical, step-by-step ETI way!

Just imagine yourself with the responsibility of running a radio or TV station. Or in command of an airport control tower. Imagine yourself as a technician on the job installing, troubleshooting or getting it all together for a two-way communications system at the local police or fire department. It's all great work and you can get it!

You may find hundreds of doors opening for you with that FCC license. An FCC license is *required* for thousands of exciting jobs. You'll be in demand! You'll be headed for a future doing a job you like. And you'll be getting a paycheck you'll like every bit as much. You'll have all the security and confidence that comes with being a *licensed professional* in an important career specialization.

Is FCC-license preparation hard to learn at home?

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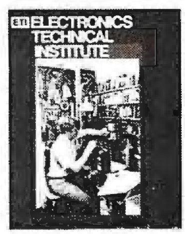

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New Literature

HUSTLER CB & MONITOR ANTENNAS

New-Tronics' 20-page, illustrated catalog of Hustler CB and monitor antennas includes telescopic and dual antenna models, as well as mounting hardware, gutter clips, coax leads, matchers and phasing harnesses. Monitor antenna systems described include the Monitor Match Model 5M5, which accomplishes the functions of four separate antennas, and the Discone Model DCX, a wide-band antenna with complete coverage from 40 to 700 MHz. Address: Sales Department, New-Tronics Corporation, 15800 Commerce Park Drive, Brookpark, OH 44142.

SILTRONIX CB PAMPHLET

A new, pocket-sized pamphlet from Siltronix lists the popular trucker CB channels used on the major highways of the continental United States. Listed by state, the booklet designates the most common trucker channels, giving specific exceptions and secondary channels. Also included is a table of commercial radio stations that make announcements warning drivers of weather conditions, detours, and other obstacles along major routes. Address: Siltronix, 269 Airport Rd., Oceanside, CA 92054.

DISCRETE SEMICONDUCTOR GUIDE

A new 112-page guide from Intersil describes the company's complete line of field effect, dual field effect and dual bipolar transistors. Products are grouped by typical application with complete specifications and a comparison table of key parameters for each device. Applications are illustrated with detailed schematics, and there's a section on chips and wafers. A comprehensive cross reference and a complete listing of parts in alphanumeric order are also included. Address: Intersil, Inc., 10900 North Tantau Ave., Cupertino, CA 95014.

EDMUND CATALOG #762

Edmund Scientific announces its latest catalog #762. The 172-page, illustrated catalog describes over 4500 unusual and hard-to-find items in science, optics, and electronics, including a variety of telescopes, binoculars, microscopes, photographic attachments, tools, games, and puzzles. Solar-Chron, one of the many items featured, is a solar electronic digital wrist watch with nine solar cells that use the sun or incandescent light to obtain reserve power. Another item described is the pocket-sized Executive GSR Meter, a biofeedback monitoring device to help you learn about tension-reduction techniques. Address: Edmund Scientific Co., 380 Edscorp Bldg., Barrington, NJ 08007.

BOMAN ASTROSONIX LITERATURE

Boman Industries offers literature on its line of car sound systems and citizens band products. A 16-page, four-color brochure describes its Astrosonix line of in-dash and under-dash AM, AM/FM and AM/FM/MPX car radios, cassette and 8-track cartridge car stereos, speakers, booster amplifiers and accessories. Also offered is a six-page flier describing Boman's citizens band transceivers, some featuring AM/FM-MPX radio. Address: Boman Industries, 9300 Hall Rd., Downey, CA 90241.

VOLTAGE-SUPPRESSION MANUAL

A new 108-page "Transient Voltage Suppression Manual" from General Electric has 80 pages of text on transient cause, detection and protection. Also included are a selection guide and product specification sheets for selecting GE-MOV varistors. Available for $2.50 (plus local tax) from GE Semiconductor, Electronics Park, Bldg. 7-49, Syracuse, NY 13201.

Pocket CB

New integrated circuit technology and a major electronic breakthrough brings you the world's smallest citizens band transceiver.

SMALL ENOUGH FOR YOUR POCKET

Scientists have produced a personal communications system so small that it can easily fit in your pocket. It's called the PocketCom and it replaces larger units that cost considerably more.

MANY PERSONAL USES

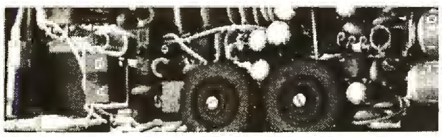
An executive can now talk anywhere with anybody in his office, his factory or job site. The housewife can find her children at a busy shopping center. The motorist can signal for help in an emergency. The salesman, the construction foreman, the traveler, the sportsman, the hobbyist—everybody can use the PocketCom—as a pager, an intercom, a telephone or even a security device.

LONG RANGE COMMUNICATIONS

The PocketCom's range is limited only by its 100 milliwatt power and the number of metal objects between units or from a few blocks in the city to several miles on a lake. Its receiver is so sensitive, that signals several miles away can be picked up from stronger citizens band base or mobile stations.

VERY SIMPLE OPERATION

To use the PocketCom simply turn it on, extend the antenna, press a button to transmit, and release it to listen. And no FCC license is required to operate it. The PocketCom has two Channels—channel 14 and an optional second channel. To use the second channel, plug in one of the 22 other citizens band crystals and slide the channel selector to the second position. Crystals for the second channel cost $7.95 and can only be ordered after receipt of your unit.



The PocketCom components are equivalent to 112 transistors whereas most comparable units contain only twelve.

A MAJOR BREAKTHROUGH

The PocketCom's small size results from a breakthrough in the solid state device that made the pocket calculator a reality. Mega scientists took 112 transistors, integrated them on a micro silicon wafer and produced the world's first transceiver linear integrated circuit. This major breakthrough not only reduced the size of radio components but improved their dependability and performance. A large and expensive walkie talkie costing several hundred dollars might have only 12 transistors compared to 112 in the Mega PocketCom.

BEEP-TONE PAGING SYSTEM

You can page another PocketCom user, within close range, by simply pressing the PocketCom's call button which produces a beep tone on the other unit if it has been left in the standby mode. In the standby mode the unit is silent and can be kept on for weeks without draining the batteries.

SUPERIOR FEATURES

Just check the advanced PocketCom features now possible through this new circuit breakthrough: 1) Incoming signals are amplified several million times compared to only 100,000 times on comparable conventional systems. 2) Even with a 60 decibel difference in signal strength, the unit's automatic gain control will bring up each incoming signal to a maximum uniform level. 3) A high squelch sensitivity (0.7 microvolts) permits noiseless operation without squelching weak signals. 4) Harmonic distortion is so low that it far exceeds EIA (Electronic Industries Association) standards whereas most comparable systems don't even meet EIA specification. 5) The receiver has better than one microvolt sensitivity.

EXTRA LONG BATTERY LIFE

The PocketCom has a light-emitting diode low-battery indicator that tells you when your 'N' cell batteries require replacement. The integrated circuit requires such low power that the two batteries, with average use, will last weeks without running down.

The PocketCom can be used as a pager, an intercom, a telephone or even a security device.

MULTIPLEX INTERCOM

Many businesses can use the PocketCom as a multiplex intercom. Each employee carries a unit tuned to a different channel. A stronger citizens band base station with 23 channels is used to page each PocketCom. The results: an inexpensive and flexible multiplex intercom system for large construction sites, factories, offices, or farms.

NATIONAL SERVICE

The PocketCom is manufactured exclusively for JS&A by Mega Corporation. JS&A is America's largest supplier of space-age products and Mega Corporation is a leading manufacturer of innovative personal communication systems—further assurance that your modest investment is well protected. The PocketCom should give you years of trouble-free service, however, should service ever be required, simply slip your 5 ounce PocketCom into its handy mailer and send it to Mega's prompt national service-by-mail center. It is just that easy.

The PocketCom measures approximately ¾" x 1½" x 5½" and easily fits into your shirt pocket. The unit can be used as a personal communications link for business or pleasure.

GIVE IT A REAL WORKOUT

Remember the first time you saw a pocket calculator? It probably seemed unbelieveable. The PocketCom may also seem unbelieveable so we give you the opportunity to personally examine one without obligation. Order only two units on a trial basis. Then really test them. Test the range, the sensitivity, the convenience. Test them under your everyday conditions and compare the PocketCom with larger units that sell for several hundred dollars.

After you are absolutely convinced that the PocketCom is indeed that advanced product breakthrough, order your additional units, crystals or accessories on a priority basis as one of our established customers. If, however, the PocketCom does not suit your particular requirements perfectly, then return your units within ten days after receipt for a prompt and courteous refund. You cannot lose. Here is your opportunity to test an advanced space-age product at absolutely no risk.

A COMPLETE PACKAGE

Each PocketCom comes complete with mercury batteries, high performance Channel 14 crystals for one channel, complete instructions, and a 90 day parts and labor warranty. To order by mail, simply mail your check for $39.95 per unit (or $79.90 for two) plus $2.50 per order for postage, insurance and handling to the address shown below. (Illinois residents add 5% sales tax). But don't delay.

Personal communications is the future of communications. Join the revolution. Order your PocketComs at no obligation today.

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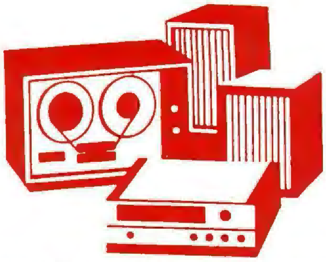


Stereo Scene

By Ralph Hodges

THE GREAT TUBE/TRANSISTOR CONTROVERSY

THE STORY, as it was told to me by a close and reliable source, goes like this. A few years ago a highly esteemed manufacturer of solid-state high-fidelity equipment was contacted by a talented group of audio amateurs who challenged him to equal the performance of their equipment — to their satisfaction — using any solid-state techniques he cared to apply. Their equipment used vacuum tubes exclusively in its signal-handling circuits and had been designed by ear as much as by instrument to satisfy the requirements of the supremely critical listener.

The manufacturer accepted the challenge and presented himself at the appointed time, with a spectrum analyzer, among other test gear, a supply of resistors and capacitors, and his stock, consumer-available electronics. He was given about a weekend to complete the test.

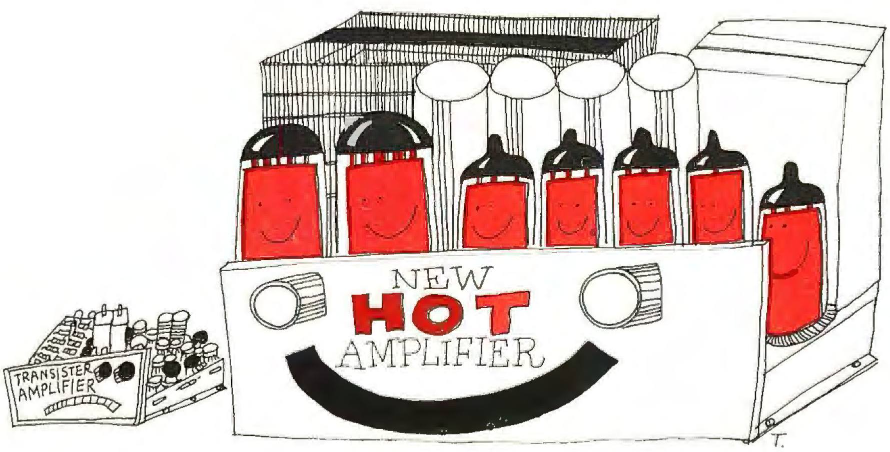
First, he analyzed the frequency response of the tube amplifier in one-third octave bands and matched the response of his own gear to that reference. Then he altered the noise spectrum of his amplifier to conform to that of the tube amplifier, adding hiss to his own designs as required. Finally, he injected just a touch of hum into his electronics — a subaudible amount at normal listening levels, but enough to provide the subliminal sense of low-frequency potency that the tube equipment's hum level suggested. Reportedly, his manipulations were so successful that not one of his challengers could consistently distinguish his solid-state amplifier from their own specially designed tube equipment, nor could they say definitely which sounded better in the long run.

A Mountain Or a Molehill? If nothing else, this anecdote demonstrates just how serious the tubes versus transistors controversy has become in the audio industry. Manufacturers of highly advanced transistorized gear are beginning to pay some attention to the experienced audiophile's views on the virtues of vacuum-tube equipment, perhaps because these preferences are steadily becoming more widespread. Vacuum-tube amplifiers and preamplifiers are briskly being sold by Audio Research, Lux (which has even developed new output and driver tubes for its designs), and Dynaco (which has had so much success with its Mark III power amplifier that it is now introducing a new tube amplifier, the 120-watt Mark VI). These three just account for the bulk of the market, but numerous smaller manufacturers are also making their contribution.

In the midst of all this activity, the manufacturers most involved are not overwhelmingly convinced that the tube itself is more desirable than the transistor. Dynaco's chief engineer, Wade Burns, says that the introduction of the Mark VI, ". . . does not contradict our feeling that in state-of-the-art audio equipment, tubes offer no distinct technical advantage over the use of modern semiconductors." And Wendell Diller, sales manager and spokesman for Audio Research, a company that deals exclusively in tube equipment, is surprisingly moderate in his views: "Tubes *per se* do not make an amplifier superior. A tube can be operated in a nonlinear fashion just as a transistor can be operated in a relatively linear fashion. We are not trying to start a tube fad. However, under the best conditions the tube is more linear than the bipolar transistor." If the major *manufacturers* of tube amplifiers are willing to concede that transistor designs can be decent or even equivalent reproducers, why is there such a polarization among amplifier users?

Defining the Difference. Analyzing the difference between tube and transistor amplifiers is not as easy as it first appears. Far from being nonlinear, a good solid-state amplifier is so linear that it can often embarrass the sine-wave signal generator used to test it. Modern tube designs can do just as well. The difference between the best of both types of amplifiers cannot amount to much more than 0.1% distortion of any sort (using standard measuring techniques). At any listening level you could stand, 0.1% distortion is lower in level than the sound of your heartbeat. You'd never hear it.

Denied any definitive help from their test gear, amplifier designers have lately fallen back on theoretical approaches and listening tests to cope with the responses from tube-oriented consumers. Bob Bird, chief engineer at ESS, neatly summarizes the listening-test criteria as centering on (1) sonic clarity, (2) bass definition, and (3) clipping characteristics. Bass definition is an area in which almost everyone, including tube proponents, feels that much vacuum-tube equipment falls short. Lawrence Niles of



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Epicure has advanced some possible explanations. The output section of any amplifier is essentially an "impedance-translating stage between the last voltage-gain stage and the speaker output terminals." Practically every vacuum-tube amplifier ever designed has used an output transformer to do this impedance translation, and, ". . . a transformer . . . exhibits considerable phase shift at both low and high frequencies. The low-frequency phase shift is a likely explanation for the loss of low-frequency definition characteristic of some tube designs."

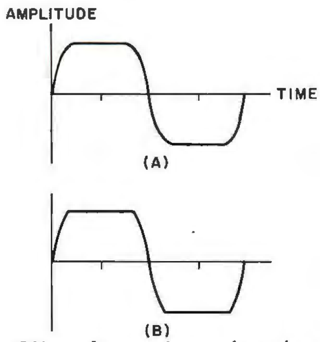

Fig. 1. Clipped waveforms in tube (A) and transistor (B) equipment.

A corollary to this is that the amplifier's output impedance tends to rise at low frequencies, which, in turn, reduces the damping factor at a point where it should be high, particularly with a vented-box (speaker system) design operating below resonance. This and problems like transformer hysteresis and core saturation, are the sources of a tube amplifier's major performance limitations in terms of bandwidth, distortion, and power handling." (Note, however, that a class-A vacuum tube amplifier can function *without* an output transformer. A suitably designed, high-power, wideband cathode follower could drive the speaker directly. This would avoid transformer-related problems. But, to my knowledge, no commercial amplifier has such an output circuit.)

"Sonic clarity" is a subjective concept that no one knows how to handle without performing listening tests. But clipping characteristics, although not so easy to generalize on as you might expect, are readily measurable, and some investigators of the tube-versus-transistor controversy have been having a field day with them.

How Does It Clip? As is well known an amplifier clips on signal peaks when the output signal voltage reaches the upper and/or lower limits of the power supply voltage. However, just before this occurs, the active output devices (tubes or transistors) are being operated in the nonlinear regions of their input/output characteristic curves. It is in such nonlinear operations that the difference between tubes and transistors becomes apparent. As illustrated in Fig. 1, the rounded corners of tube clipping are quite different from the squared-off plateaus of a transistorized amplifier. This means that a heavy dose of spurious high-order harmonics is generated by a transistor amplifier when it clips, the almost universal consensus being that these harmonics just don't sound good.

In May 1973, Russell Hamm published a paper in the *Journal of the Audio Engineering Society* that is probably the most complete guide to the observable consequences of clipping available. Hamm, a recording engineer, investigated the differences between tube and solid-state recording equipment as heard by technicians and musicians. He got such re-

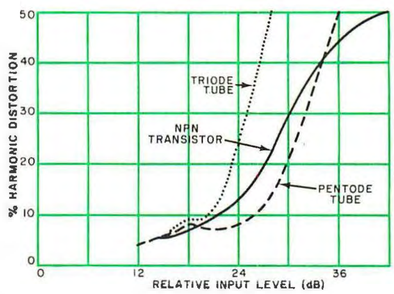

Fig. 2. Single-stage amplifier comparison of total harmonic distortion (THD).

sponses as, "With tubes there is a space between the instruments, even when they play loud . . . Transistors make a lot of buzzing" and "Transistors give a 'shattered glass' sound that restricts the dynamics." He stated further that whenever he or his associates heard "an unusually loud and clear popular-music studio recording," they investigated and found in almost every case that the recording console involved used vacuum tubes in its critical circuits.

Hamm delved pretty deeply into the physics and psychoacoustics of the situation and discovered, among other things, that the vacuum tube's clipping characteristics are not so "gentle" in terms of total harmonic distortion as is generally believed (Fig.

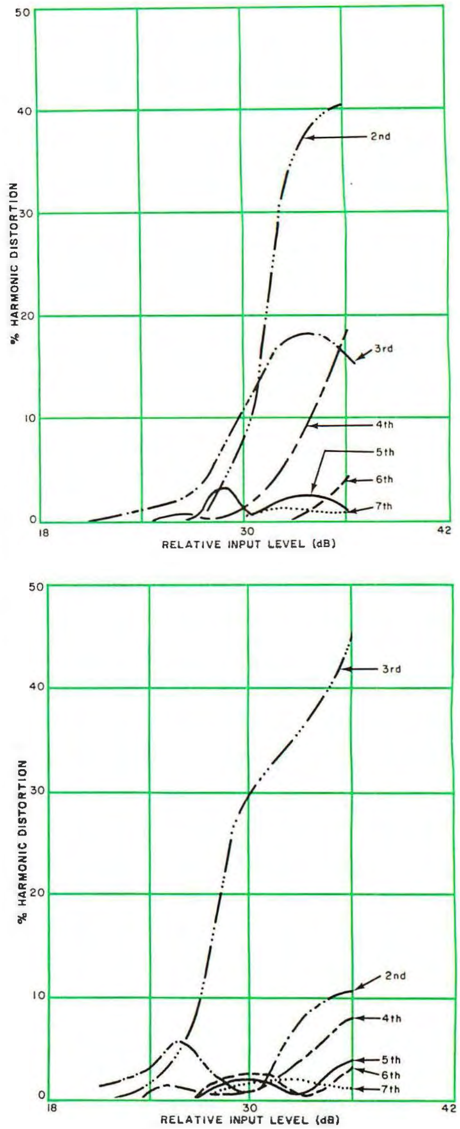

Fig. 3. Distortion components for two-stage triode amplifier (top) and for a multistage capacitor-coupled transistor amplifier (bottom).

2). But at the same time, he found reason to attribute the preference for tube sound to the spectral distribution of distortion products (Fig. 3). In a fascinating discussion based on the techniques for musical instrument design, Hamm suggested that the triode's generation of second-order harmonic distortion during overload made the sound fuller, which would account for the more satisfying dynamic range that listeners heard when tube electronics was used. He also identified harmonics above the seventh as the cause for the sharply defined "edge" we hear on tones from instruments like violins and trumpets. This "edge" is purportedly a loudness cue to the human ear. When we hear it unsupported by a strong second harmonic (presumably the result of transistor clipping), the sound is overly loud, annoying, and "glassy." When

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the distortion products include a prominent second harmonic (as in the output of a clipping triode amplifier), the sound is naturally loud, rich, and full-bodied.

Hamm's descriptions of transistor behavior read like a tube enthusiast's critique of transistor amplifiers. But who, besides recording studios, operates his equipment in a state of almost constant overload? Also, most audio enthusiasts don't object to amplifier overload when they recognize it as such. They *do* object to poor sound on relatively quiet musical passages when the amplifier can't be close to exceeding its specified power output. And, apparently, they are hearing effects from transistor amplifiers that sound remarkably like Hamm's clipping symptoms — but without any obvious possibility of clipping in the amplifier.

TIM Again. Although the concept of transient intermodulation distortion (TIM) is being taken very seriously in Europe and elsewhere, it gets almost no attention here in the U.S. Perhaps that's because it's not widely understood that TIM (like any type of distortion) can arise from numerous causes, and therefore it's tricky to isolate. Also, the mechanism of TIM is so obvious that you'd not expect an amplifier designer to overlook it. Also, it's possible that TIM has been misnamed; maybe it should be called "feedback inertia," because it invariably arises when there are high-speed events within the amplifier that are too short in duration for the feedback to affect properly.

Most transistor amplifiers use large amounts of negative feedback. They use it for various reasons, such as to extend frequency bandwidth and maintain stability and to convert 0.5% distortion figure to 0.005%, which looks very good in the test labs. But the test labs employ a steady-state sinusoid signal to evaluate amplifiers, and they allow the amplifiers to cope with the signal for a finite period of time before measurements are made. It's just possible that the amplifier under test could go crazy at the first moment the test signal is applied to it, and then settle down to a comfortable accommodation a few milliseconds later. But music almost never stands still, and TIM devotees claim that an amplifier that can't keep up with the music signal is not suitable for audio

reproduction of the highest quality.

If the amplifier under test goes crazy in these critical first few milliseconds, it has TIM. What does this mean? First of all, it means that a small fraction of the input signal gets through without being "corrected" by negative feedback. Maybe that will result in 0.5% distortion rather than 0.05%, for that instant. This is trivial. What is not trivial is that the feedback-receiving stage of the amplifier is designed to work with a lot of negative feedback, and for a moment it's not getting it! Overload is a likely result — not overload of the output stage, which might coast effortlessly through the whole process, but overload of a preliminary driver stage. If you consider the possibilities of such a situation — poor overload recovery in the stage affected or in other parts of the amplifier, current limiting in subsequent stages, etc. — you'll begin to realize why some people describe all amplifiers as having special characteristics of their own. They may not always do so for the right reasons, but they do have justifiable cause. The audible symptoms seem to point to overload, just as Russell Hamm describes it. The measurable symptoms point to driver or pre-driver stages as being responsible.

Why are tube designs comparatively free of this effect? I suggest it's because tube amplifiers don't employ a lot of negative feedback. And if you use a minimal amount of feedback, you'll get a minimum of TIM.

The Overall Outlook. Lots of people have theories why tubes sound different from transistors. Many others have theories why they don't. I believe that amplifiers, tube or transistor, can sound different from one another, for reasons essentially unrelated to the inherent characteristics of the active devices they employ. In support of my argument, I'll quote Tom Jelsing of Bang & Olufsen:

"When complete knowledge of the waveform at all stages in an amplifier is essential, it is not adequate to analyze the total transfer function from input to output in an amplifier with feedback. The transfer function must be analyzed at all points in the circuit, or at least at all possibly critical points. Some of these (analyses) are more straightforward than others, but the analysis must be made if the designer is to be certain that the signal amplitudes do not exceed the dynamic range available at every point."

I'll also quote Tomlinson Holman of Advent:

"In 1976, tube technology must be considered to be very mature; transistor technology should be considered to be approaching adolescence. A comparison of the average tube unit with the average transistor unit would certainly demonstrate a lopsided balance in favor of the tube unit, simply because only a few high-quality tube units remain on the market at this time.

"I see no *inherent* advantage with any of the possible technologies: bipolar transistors, field-effect transistors, tubes, or integrated circuits. Tubes have frailties and can definitely age. Transistors can be nonlinear if tube-based designs are translated to solid state. Yet very fine transistor designs have evolved by treating transistors as what they are." Amen! ◈

Hobby Scene Q&A

Have a problem or question on circuitry, components, parts availability, etc.? Send it to the Hobby Scene Editor, POPULAR ELECTRONICS, One Park Ave., New York, NY 10016. Though all letters can't be answered individually, those with wide interest will be published.

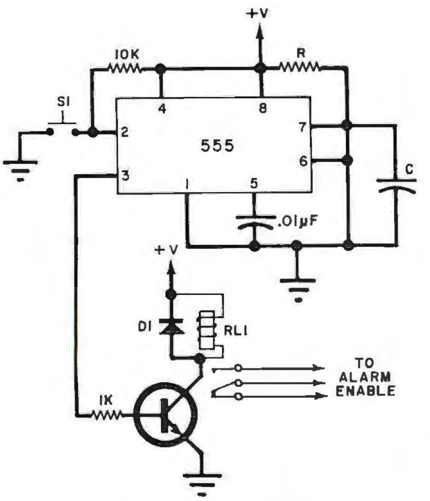
By John McVeigh

ALARM EXIT DELAY

Q. ***I want to add an exit delay (about 30 seconds) to my 6-volt alarm system. Any ideas?***

—Scott Goldman, Great Neck, NY

A. We've received a number of similar requests, some of which sought a circuit to turn *off* an alarm siren, say, five minutes *after* it was enabled. The circuit shown can perform either function. As an exit delay, push *S1* to activate. Then T seconds later (T = 1.1RC),



relay *K1* will be deenergized. Use the relay contacts to activate the alarm sensor circuit (however this is done in your alarm system). To turn off a siren, *K1's* contacts can simply interrupt the siren power supply. To activate this circuit, pin 2 of the 555 must be momentarily brought to ground — through an inverted one-shot, or similar means. Use a momentary pushbutton for *S1*, a general-purpose diode for *D1*, and a low-voltage (6-18 V, depending on supply) dc relay for *K1*. Be sure to select a switching transistor (*Q1*) which can handle the relay coil's current.

REFRIGERATORS AND TURNTABLES

Q. ***Whenever my refrigerator turns on, I hear a loud pop through my speakers. But this only happens when I'm using my turntable. The problem isn't due to noise on the ac line, because it still happens with the turntable power cord unplugged.***

—Tom Russell, Providence, RI

A. The noise could be due to one of two things. First, a physical vibration could cause a transient movement of the stylus. (You didn't mention whether or not you removed the tone arm from the disc when you removed the cord). Shock-mounting the turntable with foam rubber should take care of that. The more probable cause is the strong magnetic field generated by the compressor motor at the instant it turns on. It could induce a transient signal on the cable to the preamp, and thus be amplified and fed to the speakers. Alternatively, the field could induce a signal on a lead in the phono preamp itself. Such problems have no easy cure. But you'd best start by slipping the phono signal leads into a length of tubular copper braid, which should be grounded to the amplifier chassis. In turn, the chassis should be connected to a *good* earth ground. If the problem persists, you might have to shield the entire phono preamp circuit with fine screening bolted to the chassis. Finally, rotating the amplifier so that the lead picking up the signal is parallel to the field's line of force will weaken any residual induced signal.

24V to 12V

Q. ***I have a 24-volt, 1 ampere dc power supply. I would like to step down the output to 12V dc so I can power my auto tape player and CB mobile transceiver in the house. What do I need to accomplish this task?***

—P.C., New Jersey

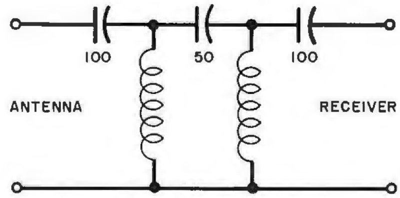
A. Three simple options come to mind. First, you could insert a 12-volt zener diode in series between the 24-volt ouput and the +12-volt lead of the tape player. However, at one ampere maximum, you would need a zener with a dissipation of 12 watts. That could be done by paralleling two matched 12-volt, ten-watt zeners. But high power zeners can be expensive. Alternatively, a 12-volt, low power zener, limiting resistor, and pass transistor could be used. A cheaper solution would be to use a 12-volt IC regulator. The Radio Shack No. 276-1771 is a suitable regulator in a T0-3 can. The INPUT pin should be connected to +24 volts (it is rated at +30 V max.), the OUTPUT pin to the +12-V lead of the player, and the case to an adequate heat sink and both chassis grounds. The regulator costs only $1.59 as listed in the 1976 Radio Shack catalog. However, due to limitations of your power supply, only 1 A max. at 12 volts can be obtained. Many tape players and transceivers draw about 1.5 A. Getting more current output would mean modifying the power supply's transformer and built-in regulator.

HIGH-PASS FILTER

Q. ***Do you have a simple circuit for a high-pass TV filter for use with 75-ohm coaxial lines?***

—Murray Becker, Brooklyn, NY

A. Here's a filter that can be used with coax-fed TV and FM receivers. Capacitors are silver mica types, rated in picofarads. The inductors are three



turns of No. 14 wire, ¾" (19.05-mm) diameter, spaced eight turns to the inch. It will attenuate all signals below 40 MHz, but will pass TV and FM signals. For best results, the filter should be constructed in a shielded enclosure, but shielding will not always be necessary.

MOBILE STEREO AMPLIFIER

Q. ***I want to build the "Mobile Stereo Amplifier" in the February issue, but I can't find the NE540 or SE540 driver chips. Do you know of any sources?***

—Michael McMahan, Urbana, Ohio

A. Surprisingly, I've received a large number of similar requests. I really didn't expect that to happen, because the 540 is offered by many surplus dealers in the back of PE. Some of them even sell a 540 and the complementary output transistors as one package. At any rate, referring to the June issue, you will find the following dealers offering the 540 driver IC: Solid State Sales (P. 108); James Electronics (P. 111); Quest Electronics (P. 117); and Digi Key (P. 118). In some recent issues of PE, I've counted as many as ten dealers offering the NE 540 or SE540!

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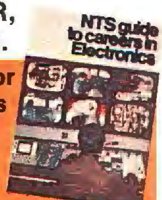

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news HIGHLIGHTS

TV Rivals Phones & Cars
It has taken only 30 years for television to rival both the telephone and motor vehicle in worldwide popularity, according to RCA. Based on latest available statistics, it is estimated that there are 364 million TV receivers worldwide, compared with 360-million phones and 300-million cars and trucks. The U.S. leads in all categories, with approximately 120-million TV receivers, 144-million phones, and 130-million motor vehicles. The U.S.S.R. comes in second with 50-million TV receivers, 15.8-million telephones, and 7-million vehicles, while Japan is third with 25.5-million, 41.9-million and 25-million respectively. The size of the worldwide TV market is impressive, considering that the industry growth began only in 1946, whereas the telephone is 100 years old and the car is almost 80 years old.

RCA Tube Business To GTE
RCA Corp. has sold machinery, parts, raw materials, work in process, and technical data related to the manufacture of Nuvistors and certain other receiving tubes produced at its plant in Harrison, N.J. to GTE Sylvania, Inc. On January 15, 1976, RCA announced its decision to cease manufacturing operations at its Harrison plant by July 30 and that efforts were being made to sell the manufacturing tools and equipment. With all receiving tube manufacturing ending in April, RCA stated its intention to close the Edison, N.J. warehouse and distribution center by the end of June 1976.

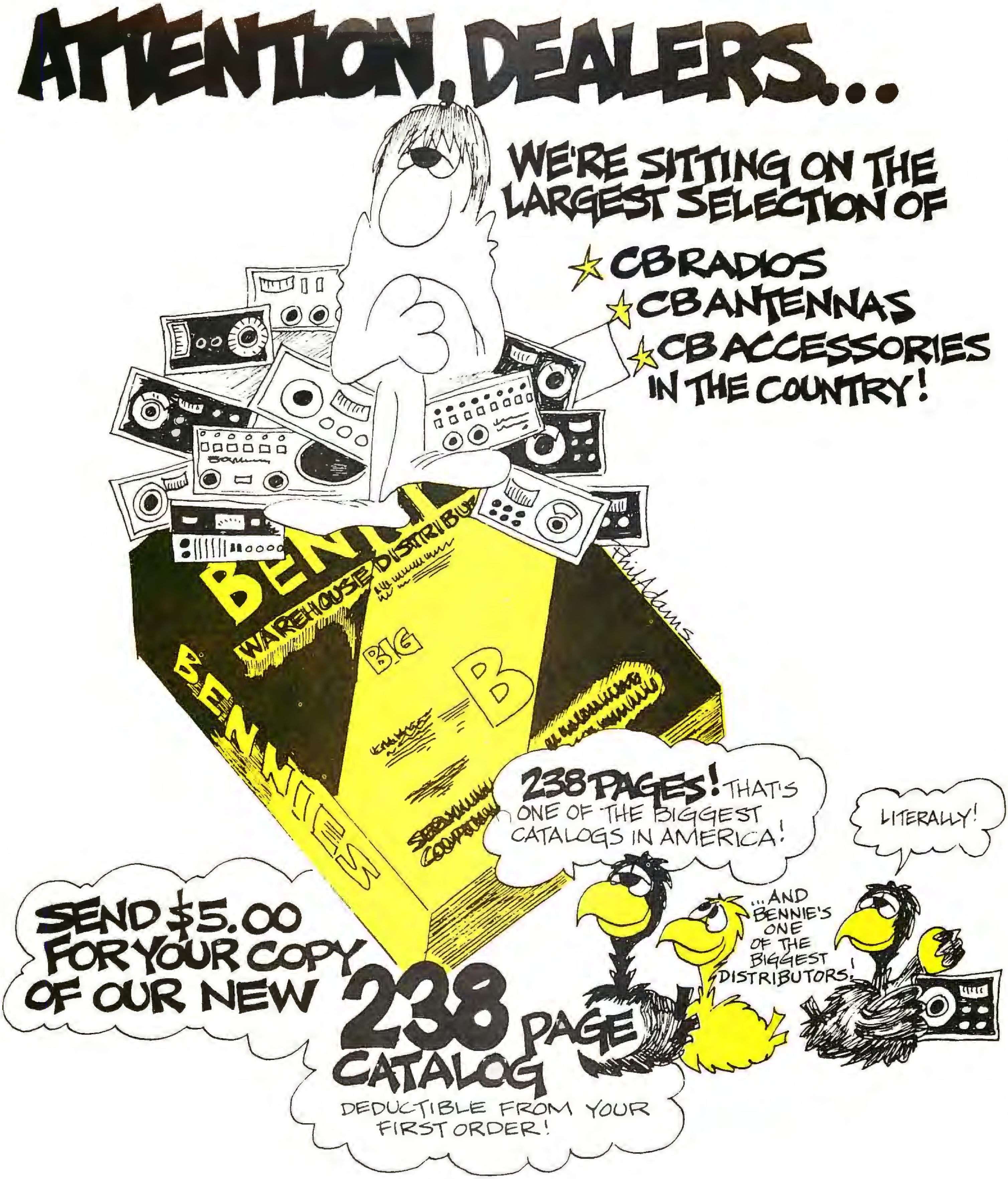
LED Watch Circuit Extends Battery Life
Gruen Industries, Inc., has announced a new electronic circuit that increases battery life by 65% in LED digital watches. The circuit was developed through Gruen's efforts to produce thinner, more fashionable solid-state watches for women without sacrificing the battery life. Batteries rated at 6600 cycles operated on an average of 25 cycles per day yield a life of 264 days in conventional LED watches. With Gruen's new circuit, the battery is said to last an average of 11,000 cycles, or 440 days. The new circuit will be used only in the company's Telstar lady's watches, but men's modules are slated for early development.

MDS Threatens Cable TV
Although it has been around for more than half a decade, Multipoint Distribution Service (MDS) has during the past year or so become a widespread concern in the cable TV world. Since mid-1975 when multiple system operators entered into agreements with the largest MDS owner to provide pay-TV service to communities via MDS technology, cable-TV operators have seen it as a growing threat to them. The cable-TV people feel that MDS will "skim the cream off the urban market" by providing pay services to multi-dwelling housing units at costs far below those of wiring for cable. Others view MDS as a communication "link" with the potential for expanding the scope and flexibility of a cable system by providing a new means of delivering programming to cable headends.

Walkie-Talkies Move From 27 MHz
Acting on Docket 20119, the Federal Communications Commission has shifted the 100-mW walkie-talkie that can be operated without a license from the 27-MHz Citizens Band to 49.82 to 49.90 MHz. Manufacture of the 100-mW (27-MHz) CB transceivers is permitted to continue for a year, and their use will be permitted until 1983.

Calculators For The Blind
The American Foundation for the Blind has introduced two calculators—one braille and the other an audible unit—for blind and visually handicapped persons. The braille calculator was adapted by AFB's engineering division from a standard portable calculator. It is a five-function unit with floating decimal point, mounted in a box and equipped with a single braille cell. The cell, which uses four dots of the basic six-dot braille notation, is activated by depressing the "read" button at the front of the instrument. The digits and decimal point displayed on the visual readout are presented in sequence in the form of small pins which pop up to form a braille digit. The audible version has a 24-word vocabulary which announces every entry and result. It has six basic functions, accumulating memory, automatic constant, change-of-sign key, floating decimal point, and 8-digit display. The speech key can be pressed repeatedly to announce what is on display without initiating further calculations. The speaker is loud enough for small classrooms and there is an earphone for private listening AFB's catalog, "Ideas for Better Living," describes these units along with several hundred other devices designed for the blind. Write to Aids and Appliances Division, AFB, 15 W. 16th St., New York, NY 10011, for a free copy.

Magnetic Recording Tape to Smithsonian
A piece of the world's first magnetic recording tape has been presented to the Smithsonian Institution by BASF Wyandotte Corporation. The company developed magnetic tape in Germany in 1932 and began commercial production in July 1934 at BASF's plant in Ludwigshafen, Germany. The 1934 tape was made of cellulose acetate, coated with carbonyl iron powder. It could be played on one side only and was further limited by a playing speed of one meter per second. Even so, this was an improvement over the steel wire which had been used until then since the magnetic tape was lighter than steel and could be cut and spliced.



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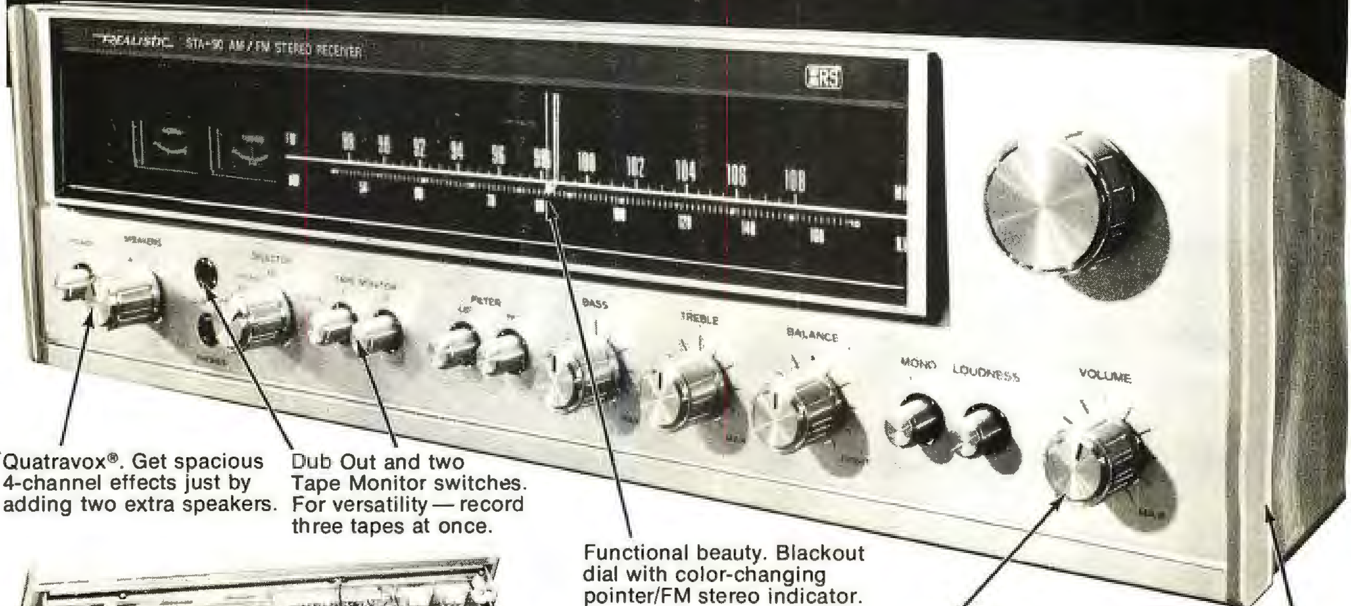

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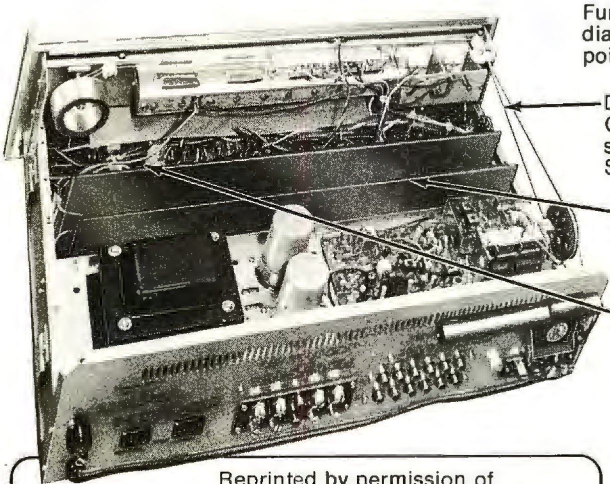

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Response: 20-20,000 Hz ±2 dB
IM Distortion: 0.3% at 30W
Phono Overload: 150 mV
Hum and Noise (dB): Phono 1, −60; Aux 1, −75

FM Tuner Specs
Sensitivity: 2.0 μV IHF
S/N Ratio: 65 dB
Separation: 35 dB at 1 kHz
Total Harm. Dist.: 0.8%
Capture Ratio: 2 dB
Selectivity: 70 dB

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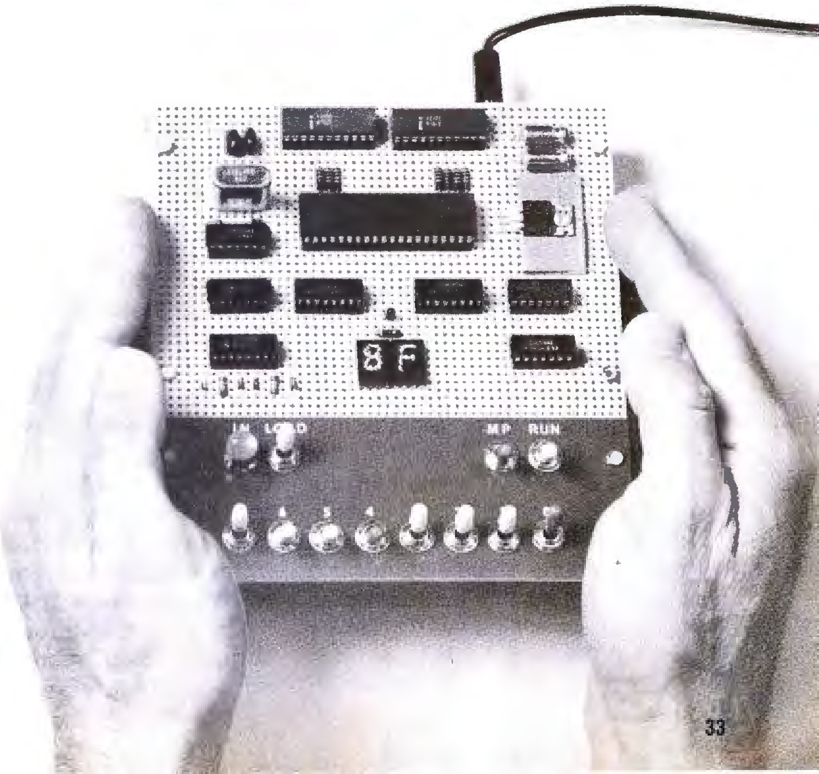
Simple-to-build computer trainer can be expanded for advanced applications.

BY JOSEPH WEISBECKER



THERE are basically two ways in which you can get involved with microcomputers on the nonprofessional level. You can buy one of several reasonably priced hobby computer kits, add a TV or typewriter terminal, and learn to use high-level language. On the other hand, you can build your own inexpensive system from scratch. This permits you to experiment with simple applications that do not require an expensive terminal or a large memory. You can communicate with the computer in a relatively simple language.

The "Elf" microcomputer project gives you the latter category of computer system—for about $80. It is an excellent hardware and software trainer that uses machine language and can be easily expanded to do just about anything a full-blown microcomputer can. Packaging, however, is up to you.

The basic Elf has toggle-switch input, hex LED display, 256 bytes of RAM, four input lines and a latched output line. It can be used to play games, sequence lights, control motors, generate test pulses, count or time events, monitor intruder-alert devices, etc. You can do all these things while learning how to program in order to produce a "real" output to determine whether or not the program you designed works. If you prefer not to control or time things, a simple LED can be used to indicate whether or not your program works.

Our focus here is on the construction of the low-cost computer and some simple examples of programming.

Design Details. The heart of the Elf microcomputer is the new RCA CDP1802 COSMAC microprocessor chip that sells for less than $30. The chip can use any combination of standard RAM and ROM devices and can address up to 65,536 (65 k) bytes of memory. It has flexible programmed I/O and program-interrupt modes, an on-chip DMA (direct memory access), four I/O flag inputs directly tested by branch instructions, and a 16 × 16 matrix of registers for use as multiple program counters, data pointers, or data registers.

Other features of the 1802 chip include voltage operation between 3 and 12 volts dc at very low current drain, TTL compatibility, built-in clock, and simplified interfacing. There is also a built-in program load-

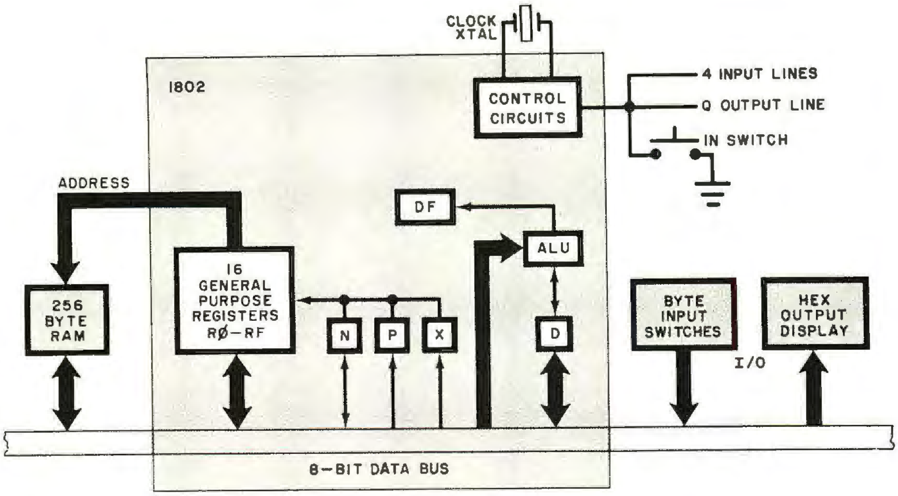


Fig. 1. Block diagram of basic computer. Up to 65K bytes of memory, 91 instructions, and varied I/O ports can be added as the system grows.

ing capability that allows you to load a sequence of bytes without having to toggle in a new address for each byte. No ROM is required for the minimum trainer system described here. The multiple program counters permit some interesting programming "tricks," and the many single byte instructions keep programs short.

A block diagram of the Elf system is shown in Fig. 1. The pinout for the 1802 microprocessor chip is shown in Fig. 2.

Basic Operation. The key to understanding the computer is the method used for addressing the memory. At first, the procedure may appear to be complicated, but you will soon see that it is not difficult.

The 1802 chip contains 16 general-purpose registers, each holding 16 bits (two bytes) of memory addresses or data. The registers are labelled R0 through RF to conform to the hexadecimal numbering system, as shown in Fig. 3. (In the diagrams, and in computer technology in general, a Danish zero—a zero with a slash through it—is used to distinguish zero from a capital letter O.) Hence, if we refer to the low-order, or least-significant, byte of R1, we can call it R1.0, while the high order byte of RF would be called RF.1.

There is also an 8-bit D register that is used to move bytes around. In the instruction set shown in part in the Instruction Subset Table, note that the 8N (8 with a digit) code will copy a low-order general register byte into register D. Writing this instruction as 81 in a program will cause R1.0 to be copied into D when the instruction is executed. We can then use instruction BF (BN in the table, with B and a digit) to copy the D byte into RF.1. It takes two bytes, 81 BF, to transfer a byte from R1.0 to RF.1 via temporary holding register D. The byte in D can also be used in arithmetic operations performed by the ALU (arithmetic logic unit) circuits.

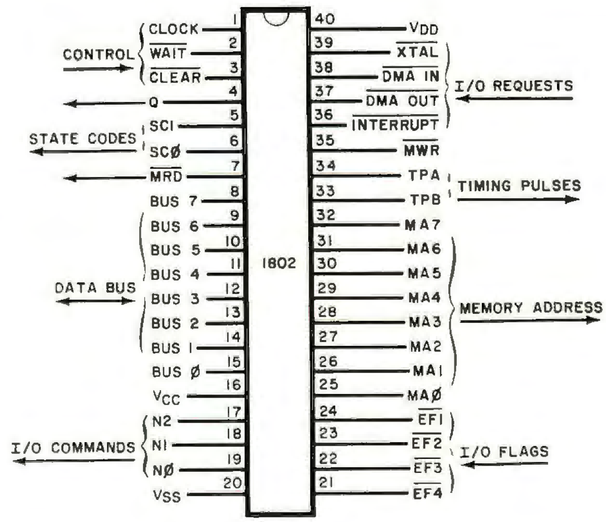


Fig. 2. Pin out for the CDP1802 COSMAC microprocessor.

There are three other important registers that are labelled N, P, and X. Each can hold a 4-bit digit that is used to select one of the 16 general-purpose registers. For example, if you wanted to talk about the general-purpose register selected by the hex digit in X, you would call it RX. If you wanted just the low-order byte of RX, call it RX.0. RN would refer to the general-purpose register designated by the 4-bit digit currently contained in N; if the digit is 4, RN = R4.

The general-purpose registers can contain 16-bit memory addresses. Suppose register R3 contains data 0012. M3 would mean the memory location specified by the contents of R3, and M(0012) means memory location 0012 directly. MX means the memory location addressed by the contents of the general register selected by the current digit in X. If X = 3, MX = M3; if R3 = 0012, MX = M3 = M(0012).

Since the basic computer has only 256 bytes of memory, we use just the low-order bytes of the general registers to address the memory. In expanded-memory systems, you can use the high-order bytes of the general-purpose registers to select individual 256-byte pages of random-access memory (RAM).

The memory contains both instructions and data bytes. Instruction bytes tell the computer what to do with the data bytes. One-byte instructions have two hex digits, where high-order bits 7, 6, 5, and 4 tell the computer what type of operation to perform. Low-order bits, 3, 2, 1, and 0 are usually placed in the N register when a new instruction is fetched from memory.

Any one of the general-purpose registers can be used as a program counter. The program counter addresses instruction bytes in memory. Each time an instruction is fetched from memory, the program counter is

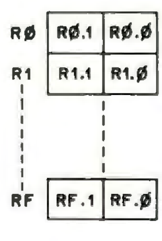


Fig. 3. The 16 registers in the 1802 are labelled RØ through RF (hex).

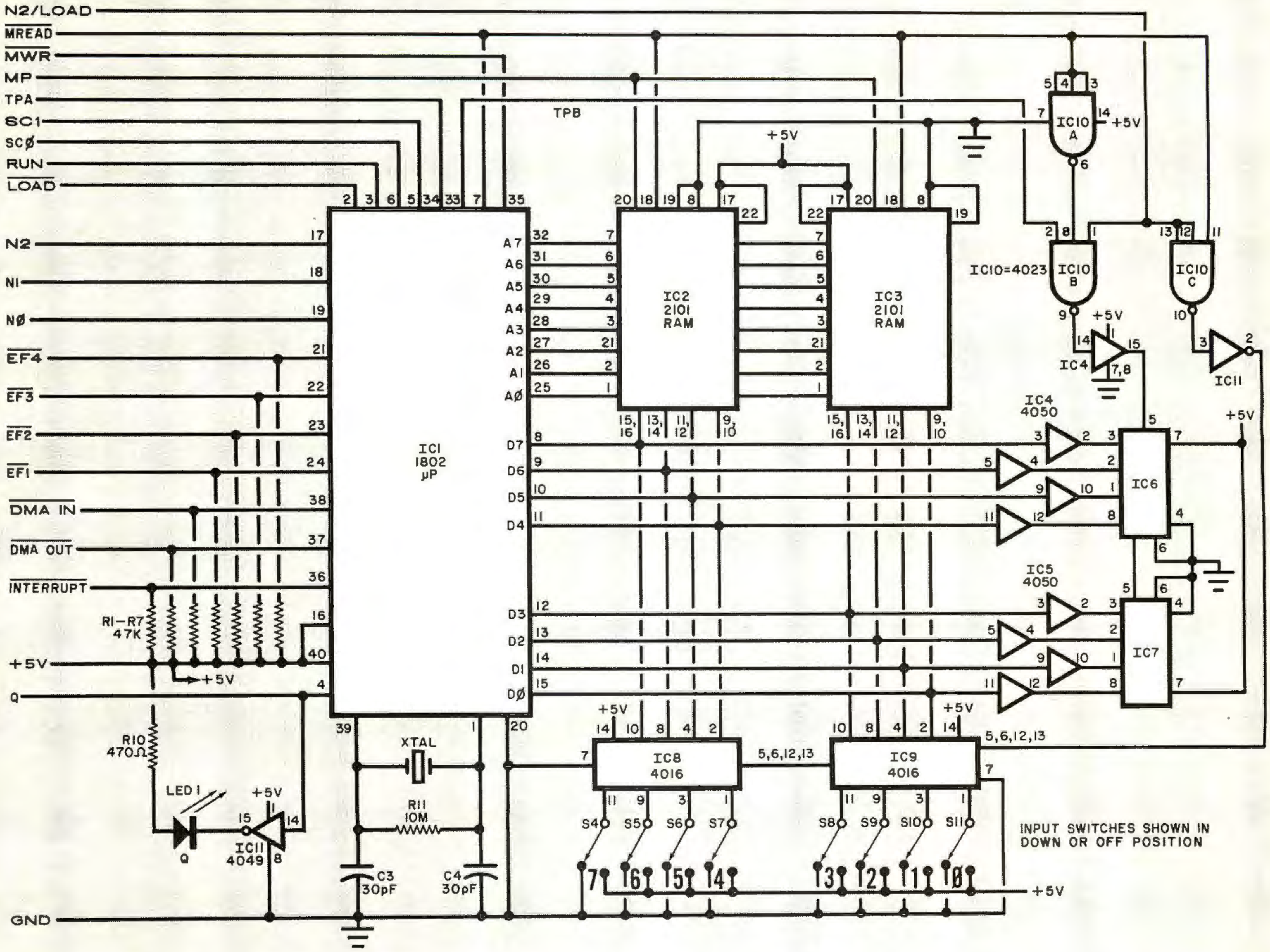


Fig. 4. Complete circuit for the Elf computer. Identified connections on the left go to the "front panel" with the eight data switches. The remaining can be left "floating" at 1802, or tied to terminal strip.

PARTS LIST

C1, C2—10-μF, 16-volt electrolytic capacitor
C3, C4—30-pF disc capacitor
D1 through D6—IN914 switching diode
IC1—CDP1802 COSMAC microprocessor chip (RCA)
IC2, IC3—2101 (256 × 4) static RAM IC
IC4, IC5—4050 noninverting hex buffer IC
IC6, IC7—Hex LED display (H-P No. 5082-7340)
IC8, IC9—4016 quad bilateral switch IC
IC10—4023 triple 3-input NAND gate IC
IC11—4049 inverting hex buffer IC
IC12—4013 dual D flip-flop IC
IC13—LM309K 5-volt regulator IC
LED1—Red light-emitting diode
R1 through R9—47,000-ohm, ¼-watt resistor
R10—470-ohm, ¼-watt resistor
R11—10-megohm, ¼-watt resistor
S1 through S11—Spdt toggle switch
S12—Pushbutton switch with one set each normally open and normally closed contacts
XTAL—1-to-2-MHz crystal (see text)
Misc.—5½" × 4" (14 × 10.1 cm) perforated board with 0.1" (2.54 cm) hole spacing; 5½" × 2" (14 × 5.1cm) piece of thin aluminum; ¾" × ⅜" (19.1 × 9.5 cm) pine for chassis rails; 14-pin IC sockets (4); 16-pin IC sockets (3); 22-pin IC sockets (2); 40-pin IC socket; connector for power supply; 9-volt, 350-mA dc power source; 1¼" × ¾" × ⅛" (31.8 × 19.1 × 3.2 mm) piece of aluminum; dry-transfer lettering kit; machine and wood hardware; hookup wire; solder; etc.
Note: the CDP1802 COSMAC microprocessor chip is available from any RCA parts distributor as is the COSMAC user manual.

automatically incremented so that it points to the next instruction to be fetched. Branch instructions can be used to change the address in the program counter to permit jumping (branching) to a different part of the program when desired. The digit in the 4-bit P register specifies which 16-bit general-purpose register is being used as the program counter.

Timing Sequence. Since many of the 1802 microprocessor's instructions are only one-byte long and require two machine cycles, the first cycle is always an instruction fetch, or memory read. The fetched instruction is executed during the next machine cycle, which could be a memory-read, memory-write, or register-transfer type of cycle.

Program execution always consists of a sequence of fetch-execute cycles, and the two SC0 and SC1 lines (see Fig. 4 and Fig. 5) indicate what type of cycle is being performed according to the following criteria:

SC1	SC0	Type of Machine Cycle
0	0	instruction fetch
0	1	instruction execute
1	0	DMA in/out
1	1	interrupt

Direct memory access (DMA) and interrupt are special types of cycles, which we will discuss later.

Circuit timing is shown in Fig. 6.

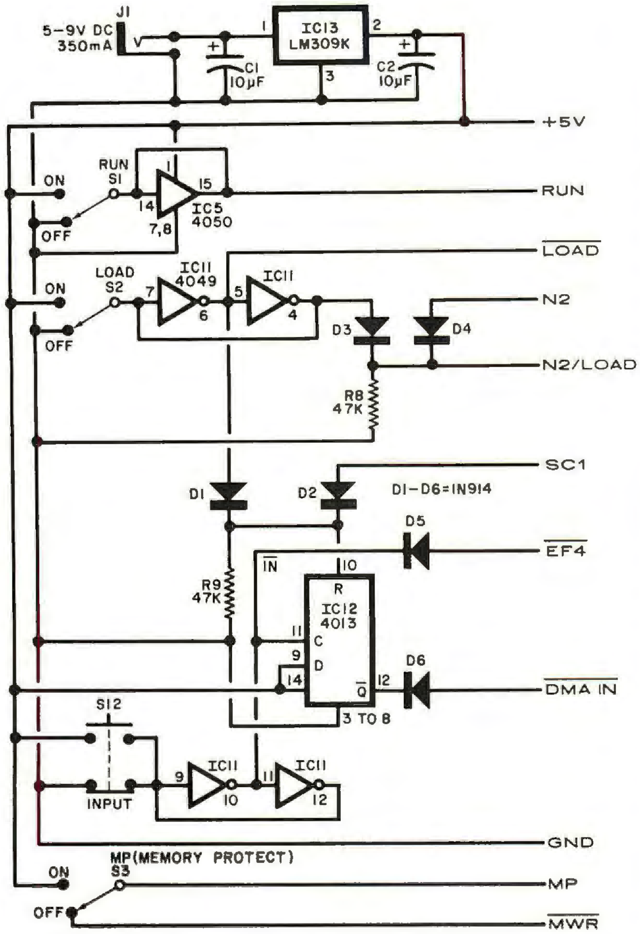


Fig. 5. Control circuits for the computer. Connections at right go to similarly marked connections on main circuit.

Note that each machine cycle requires eight clock pulses.

The microprocessor has an internal single-phase clock circuit. Connecting a crystal between pins 1 and 39 of the 1802 chip causes the clock to run continuously. If desired, *XTAL, C3, C4,* and *R11* can be omitted and an external clock with a 5-volt swing can be substituted between pin 1 and ground.

During each machine cycle, timing pulses TPA and TPB are available at pins 33 and 34 of the 1802. TPA occurs at the beginning of each machine cycle and can be used to clock the high-order byte of a 16-bit memory address into a memory page-selection register. Note that the 1802 sends out memory addresses as two 8-bit bytes. The high-order byte appears on address lines A0 through A7 first. Then the low-order byte is held on the A0 through A7 lines for the remainder of the machine cycle. This low-order address byte can, by itself, specify one of 256 locations in the minimum 256-byte memory.

TPB occurs toward the end of the machine cycle and is used to clock a byte from the RAM into an output device (such as the hex display used here). An input byte, to be stored in the RAM, is gated to the bus for the duration of the input (memory-write) machine cycle so that no time pulse is needed for input bytes.

The $\overline{\text{MREAD}}$ line is low during any memory-read machine cycle. When low, it opens the pin-18 RAM data output gates of *IC2* and *IC3*, permitting the byte stored in the RAM location addressed by A0 through A7 to appear on the data bus. The RAM's access time is such that the output byte appears on the bus prior to TPB. The bus byte from the RAM can then be clocked into an internal register of the 1802 or clocked to an external register (such as the hex display) with TPB, depending on the type of instruction being executed.

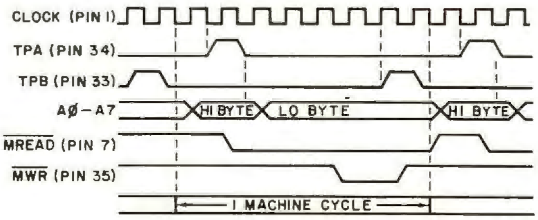
When the 1802 is performing an instruction cycle that requires a byte to be stored in the RAM, the $\overline{\text{MREAD}}$ line is held high to disable the RAM output bus gates. The microprocessor then causes the byte stored in the RAM to be gated onto the bus during the memory-write cycle. This byte can come from an internal register of the 1802 or from an input device (such as switches), depending on the type of instruction being executed. The 1802 then generates a low memory-write pulse ($\overline{\text{MWR}}$) that causes the bus byte to be stored in the RAM location addressed by the A0 through A7 lines.

Circuit Operation. Using Fig. 4, Fig. 5, and the Instruction Subset Table, we can now discuss the logic of the Elf microcomputer. The RAM address is sent out on lines A0 through A7. Eight tri-state bidirectional bus lines are used to transfer the data bytes back and forth between the 1802's registers and the *IC2-IC3* RAM. A RAM byte can be transferred to hex displays *IC6* and *IC7* via the data bus, using *IC4* and *IC5* to supply the current drive for the displays. Displays *IC6* and *IC7* contain latches to store the display byte.

The basic clock frequency of the processor is determined by *XTAL*, which should not go above 2 MHz in this circuit. The $\overline{\text{MREAD}}$ and $\overline{\text{MWR}}$ lines control the read and write cycles of the RAM, while TPA and TPB provide the timing pulses. TPA can be used for memory expansion address latching, TPB to clock bytes into output circuits. SC0 and SC1 indicate the type of cycle being performed by the 1802.

The N0, N1, and N2 lines are used to select input or output devices. In the Elf, selection can be made among four input and four output devices. The table details the values of the N0, N1, and N2 lines during the machine cycle in which an input or output instruction is executed. Instructions 69, 6A, 6B, 61, 62, and 63 are spares that can be used to add I/O devices or ports to the computer. When 6C is executed, the N2 line goes to a logic-1 state and the bus byte is written into the RAM. Since this is a write cycle, $\overline{\text{MREAD}}$ will be high. With both N2 and $\overline{\text{MREAD}}$ high, the output of gate *IC10C* will be low, putting the input toggle switch byte on

Fig. 6. Microprocessor timing. One machine cycle requires eight clock pulses. TPA and TPB control various functions, both on and off the computer.



ONE BYTE INSTRUCTIONS	
1N	RN+1
2N	RN-1
8N	RN.0→D
9N	RN.1→D
AN	D→RN.0
BN	D→RN.1
4N	MN→D,RN+1
5N	D→MN
DN	N→P
EN	N→X
7A	0→Q (LIGHT OFF)
7B	1→Q (LIGHT ON)
F0	MX→D
F1	MX or D→D
F2	MX and D→D
F3	MX xor D→D
F6	SHIFT D RIGHT,BIT 0→DF
76	ROTATE D RIGHT,DF→B7,B0→DF
FE	SHIFT D LEFT, BIT 7→DF
7E	ROTATE D LEFT,DF→B0,B7→DF
F5	MX-D→D,CARRY→DF
F7	D-MX→D,CARRY→DF
F4	MX+D→D,CARRY→DF

TWO BYTE INSTRUCTIONS	
30MM	GO TO MM
31MM	GO TO MM IF Q=1
39MM	GO TO MM IF Q=0
32MM	GO TO MM IF D=00
3AMM	GO TO MM IF D≠00
33MM	GO TO MM IF DF=1
38MM	GO TO MM IF DF=0
34MM	GO TO MM IF EF1=1
3CMM	GO TO MM IF EF1=0
35MM	GO TO MM IF EF2=1
3DMM	GO TO MM IF EF2=0
36MM	GO TO MM IF EF3=1
3EMM	GO TO MM IF EF3=0
37MM	GO TO MM IF EF4=1 } IN
3FMM	GO TO MM IF EF4=0 } SWITCH
F8KK	KK→D
F9KK	KK or D→D
FAKK	KK and D→D
FBKK	KK xor D→D
FDKK	KK-D→D,CARRY→DF
FFKK	D-KK→D,CARRY→DF
FCKK	KK+D→D,CARRY→DF
7CKK	KK+D+DF→D,CARRY→DF

ONE BYTE INPUT INSTRUCTIONS		N2	N1	N0
69	BUS→MX,D	0	0	1
6A	BUS→MX,D	0	1	0
6B	BUS→MX,D	0	1	1
6C	INPUT SWITCH BYTE→MX,D	1	0	0

1-BYTE OUTPUT INSTRUCTIONS		N2	N1	N0
61	MX→BUS,RX+1	0	0	1
62	MX→BUS,RX+1	0	1	0
63	MX→BUS,RX+1	0	1	1
64	MX→HEX DISPLAY,RX+1	1	0	0

Instruction Subset Table shows required sequence of steps.

the bus so that it can be stored at the memory location addressed by RX. This input byte will also be placed in the 1802's D register.

When a 64 instruction is executed, N2 is high and $\overline{\text{MREAD}}$ is low, making the output of *IC10C* high and preventing the input switch byte from getting onto the bus. Instead, gate *IC10B* generates an output clock pulse with TPB that clocks the RAM output byte into the hex display.

The four external flag input lines—EF1, EF2, EF3, and EF4—can be pulled low by external switches. These four lines can be tested by instructions 34, 3C, 35, 3D, 36, 3E, 37 and 3F. Note in Fig. 5 that the INPUT pushbutton switch, debounced by portions of *IC11*, is connected to the $\overline{\text{EF4}}$ line. This means that $\overline{\text{EF4}}$ = 1 when *S12* is depressed and $\overline{\text{EF4}}$ = 0 when *S12* is in its normal position.

Latched output line Q can be set high by a 7B instruction or reset to low by a 7A instruction. The Q LED comes on when Q is high. The $\overline{\text{DMA IN}}$, $\overline{\text{DMA OUT}}$, and $\overline{\text{INTERRUPT}}$ lines can be pulled low to cause these operations to occur.

The $\overline{\text{LOAD}}$ and RUN lines control the operation of the microprocessor according to the following conditions:

$\overline{\text{LOAD}}$	RUN	Mode
gnd	gnd	load
+5V	gnd	reset
gnd	+5V	—
+5V	+5V	run

RUN and LOAD switches *S1* and *S2* in Fig. 5 control the operation of the computer. With both switches set to OFF, $\overline{\text{LOAD}}$ is +5V and RUN is at ground potential. This resets the 1802. Neither TPA nor TPB are generated in the reset state and R0 = 0000, P = 0, X = 0 and Q = 0 after the 1802 is reset. When the LOAD switch is set to ON, $\overline{\text{LOAD}}$ goes low and RUN stays low, forcing the system into the load mode. Now you can load a sequence of bytes into the RAM, starting at address 0000, by setting the bytes into the input toggle switches, one at a time, and operating the INPUT switch.

In the load mode, the 1802 does not execute instructions but waits for a low to appear on the $\overline{\text{DMA IN}}$ line. When this happens, the 1802 performs one memory write cycle during which the switch input byte is stored in memory. R0 is used to address memory during the DMA IN cycle. After the input byte is stored at the address specified by R0, this register is in-

INTRODUCTION TO PROGRAMMING.

Once you have built your Elf, you must learn how to load a sequence of bytes into memory and then go back and display the sequence. Let us write a simple program that can be loaded into the memory and run.

Suppose you want to program the computer to turn on the Q LED whenever the INPUT switch is set to ON. First, you must draw a flow chart that shows the required sequence of steps (Fig. 7). Locate the correct instructions in the Instruction Subset Table. A 7A instruction will perform Step 1. Load this instruction into M(0000). Note that when the INPUT switch is not depressed, EF4 = 0. A two-byte 3F 00 instruction will jump (branch) back to the 7 A instruction at M(0000) as long as the INPUT switch is not operated (EF4 = 0). This condition is known as a "loop," and the program will stay in this loop while it is waiting for the INPUT switch to be depressed. Load 3F 00 into memory locations M(0001) and M(0002) to perform the second step in the flow chart. All GO TO MM instructions shown in the Table put MM into the low-order byte of the program counter if a GO TO condition exists. Otherwise, the next instruction in sequence is fetched by the 1802.

Loading a one-byte 7B instruction into M(0003) takes care of Step 3, while a 30 01 instruction will jump back to the 3F 00 instruction at M(0001). Load the 30 01 instruction into M(0004) and M(0005) to complete the program.

You load this 6-byte program by placing the LOAD switch on the ON position, with RUN and MP set to OFF, setting up the toggle switches for the hex number 7A, and depressing the INPUT switch. Release the INPUT switch, insert 3F and operate the INPUT switch again. Then load 00 and so on until the last byte, 01, has been stored at M(0005). If you "blow" the program, set MP to ON and LOAD to OFF. Then set LOAD to ON and operate the INPUT switch until you get to the byte immediately preceding the wrong entry. Set MP to OFF, set up the correct byte, and operate INPUT. Flip MP back to ON to protect what you have stored in memory.

To start the program running, set LOAD to the down position to reset the 1802 and set the RUN switch to ON. Nothing should happen until you depress the INPUT switch, at which time the Q LED should come on. Releasing the INPUT switch should cause the LED to extinguish. If you like, you can now observe the timing signals of the 1802 on an oscilloscope while the program is running.

Another simple program involves counting the number of times the INPUT switch is operated and then turning on the Q LED at the end of the count. The flow chart for this program is shown in Fig. 8. When you load and run this program, nothing will happen until you operate the INPUT switch five times, at which point the LED will come on and remain on. Note in Step 1 that you can change the number of times the INPUT switch is operated. Step 6 just loops on itself to terminate the program after the INPUT switch has been operated the specified number of times.

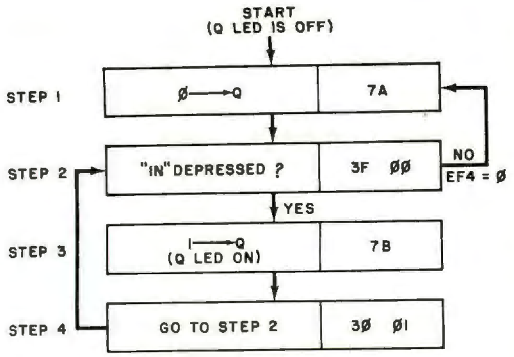


Fig. 7. Program turns on Q-LED when INPUT switch is operated.

cremented by one so that input bytes will be sequentially loaded into RAM locations. Line SC1 goes high during the DMA IN cycle so that the control circuits know when the input byte has been stored in the RAM.

Depressing and releasing INPUT switch *S12* sets flip-flop *IC12* (Fig. 5). The $\overline{Q}$ output of this stage goes low, causing the required low on the $\overline{\text{DMA IN}}$ line. The 1802 responds to this request with a memory-write cycle during which SC1 is high. During this cycle, $\overline{\text{MREAD}}$ is high and, since LOAD switch *S2* is also ON, the N2/LOAD signal causes gate *IC10C* to go high, gating the switch input byte to the data bus and storing it in memory. When SC1 goes high, it also resets *IC12*, which causes $\overline{\text{DMA IN}}$ to return to its high state. The computer then waits for the next switch input byte and LOAD switch operation.

Following each DMA IN cycle, the 1802 holds the A0 through A7 lines at the address of the byte just stored in the RAM. $\overline{\text{MREAD}}$ is also held low while waiting for the next input byte. This means that the previously loaded byte is being gated to the bus (from the RAM) while waiting for a new byte. This bus byte is continuously clocked into the hex display, since the LOAD switch is holding *IC10B* open.

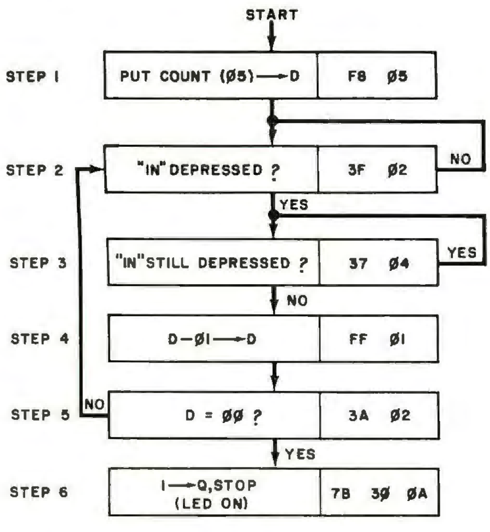


Fig. 8. Program counts number of times INPUT switch is operated.

A sequence of program bytes can be loaded into the RAM starting at M0 = M(0000) by setting the LOAD switch to the ON position, with the RUN switch set to OFF. Set the eight input switches, *S4* through *S11*, to the desired byte code (in hexadecimal) and depress the INPUT switch to store the byte in the RAM. The value of this byte will be displayed with the hex displays *IC6* and *IC7*. Repeat this procedure for each byte to be loaded. Setting the LOAD switch to OFF puts the 1802 back in the reset state where R0 = 0000, P = 0, X = 0, and Q = 0. If you wish to see what is stored in memory, set MP (memory-protect) switch *S3* and the LOAD switch to ON. Now, each time you operate the INPUT switch, successive bytes in the RAM, starting with M(0000), will be displayed.

To change a byte, proceed to the byte just before the one to be changed. Flip the MP switch to OFF, set the input toggle switches to the hex value of the new byte, and depress the INPUT switch once. This new byte will be displayed and stored in the RAM at the location following the byte at which you stopped. Place the MP switch in the ON position. You can now continue to operate the INPUT switch to sequence through the RAM without modifying the bytes in memory.

To start the executive cycle of a program, set both the LOAD and RUN switches to OFF (to reset the 1802). Then set the RUN switch to ON. The program counter is always specified by the hex digit in register P, which can be set to zero by reset so that the program counter will always initially be R0. Set R0 to 0000 by resetting so that instruction fetching, or program execution, will always begin at M(0000). Instructions will continue to be fetched from the RAM and executed until the RUN switch is set to OFF, resetting the computer. Make sure that the MP switch is OFF when running programs so that computer operation is not inhibited.

Construction Notes. Hardware assembly is relatively simple, permitting the project to be put together with ordinary perforated board with 0.1" (2.54-mm) hole spacing and IC sockets, using either Wire Wrap® or a wiring pencil. (See photo.) The perf board measures 5½"L × 4"W (14 × 10.2 cm) and is supported on a base made up of lengths of ¾" × ⅜" (19.1 × 9.5) pine. A sheet of thin aluminum provides the support for the eight toggle-type data switches. The LM309 voltage regulator IC (*IC13*) is mounted on a 1¼" × ¾" × ⅛" (31.6 × 19.1 × 3.2-mm) piece of aluminum to serve as a heat sink.

Do not mount the IC's (except the display devices) in their sockets until after all wiring is complete. Socket, switch, and component layout should be roughly the same as shown in the photo. Be sure to locate the crystal close to pins 1 and 39 of the microprocessor's socket. Then wire the circuit in accordance with the schematics in Figs. 4 and 5.

Any crystal with a frequency of between 1 and 2 MHz can be used in the Elf, or you can substitute a simple 555 or CMOS oscillator with a 5-volt signal swing between pin 1 of the 1802 and circuit ground, in which case, you will have to omit *XTAL, C3, C4,* and *R11*. There is no lower limit to the clock frequency, but most of the sample programs discussed in this series of articles are based on a clock frequency between 1 and 1.8 MHz.

Displays *IC6* and *IC7* are relatively expensive hex devices. They are the only TTL devices in the computer and, as a result, draw most of the power required by the circuit. If you wish to economize, you can substitute ordinary LED's for the displays. (Next month, we will discuss how to make the substitution.)

An inexpensive 9-volt, 350-mA dc battery eliminator, like those used as battery charger/eliminators for calculators, can be used to power the Elf.

When the computer is completely assembled, use a dry-transfer lettering kit to label all switches and positions, IC socket locations, and pins 1 of all sockets. Then, exercising the usual safety procedures for handling MOS devices, install the integrated circuits in their respective sockets.

Coming Up. In future articles, we will provide more programs as well as methods of adding other types of inputs and relay-control output circuits. We will also detail how to save programs in battery-powered COSMOS RAM's and describe a simple operating system that lets you read/write any memory location and inspect general register contents for program debugging purposes. Memory expansion, hex keyboard input, and an inxpensive video graphics display are other subjects we will cover in detail. ◈

BUYER'S GUIDE TO ANTENNA ROTATORS

How they work and what's available.

BY KRIS CARROLE

TV AND FM signals usually come into a given reception area from all directions and at various strengths. Modern TV and TV/FM antennas are highly directional to provide maximum gain. It is obvious, therefore, that to obtain the best possible reception, an antenna must be accurately aimed in the direction from which a desired signal is coming. When two or more stations are located in different directions, the only practical way of aiming an antenna is with an antenna rotator system. Too, the weaker the signals, the more accurate must be the aiming ability of the rotator system.

Basically, an antenna rotator system consists of two parts. The drive unit does all the heavy work. It mounts atop a mast, just below the antenna, where it is subjected to the elements. The other part of the system, the control box, is usually located near the TV or FM receiver where it is safe from the elements and is easily accessible to the user.

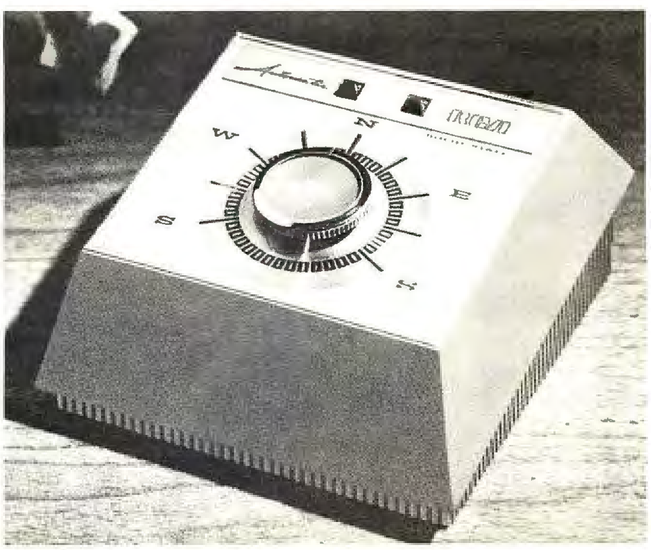
All antenna rotator systems are a great convenience, but some provide more than others. A basic system simply provides a means of rotating an antenna, while a top-of-the-line automatic rotator system can make aiming an antenna easier than tuning a TV channel or FM station. There are rotators designed to bear relatively lightweight loads and others that can accommodate loads of up to 1000 lb (455 kg).

Types of Rotators. There are basically three types or categories of antenna rotator systems in common use. In order of increasing price range, they include manual, semiautomatic, and fully automatic models (see Table).

The manual rotator is a simple system. The controller contains two pushbutton switches (one for turn-left and another for turn-right commands). The antenna rotates while one of the buttons is held in the depressed position. It stops when the button is released. The pushbutton switches are designed so that when one is depressed, the other is locked out to prevent conflicting drive commands from burning out the drive motor. The only visual indication of system operation is a light that comes on when the rotator comes to the mechanical stop at either end of rotation travel.

The major disadvantage of the manual rotator system is that each time you change a channel or station, you must experiment with the controls until you obtain the best possible reception. Except for knowing when the antenna is at one of the rotator's mechanical stop positions, there is no way of telling in which direction the antenna is pointing, short of going outside and looking at the antenna itself. There is no way of marking the controller for future reference to obtain a duplicate setting.

The big advantage of the manual



RCA's Model 10W707 fully automatic controller.

rotator system, of course, is its cost. If you don't mind experimenting with the controls and wish to save money, the manual rotator system might be just the thing for you.

The semiautomatic rotator system offers a bit more operating convenience at additional cost. It provides a visual indication of the antenna's position. The indicator is usually a compass-like dial with a pointer that indicates antenna direction. The pointer is driven by a small motor synchronized with the antenna drive. (Alliance uses a meter movement with a scale calibrated in N, E, S, W, and N to indicate antenna direction.)

The controls in the semiautomatic rotator system are the same pushbutton switches used in the simple manual systems. However, the fact that there is a visual direction indicator gives the advantage that channel and station directions can be marked on the dial for future reference.

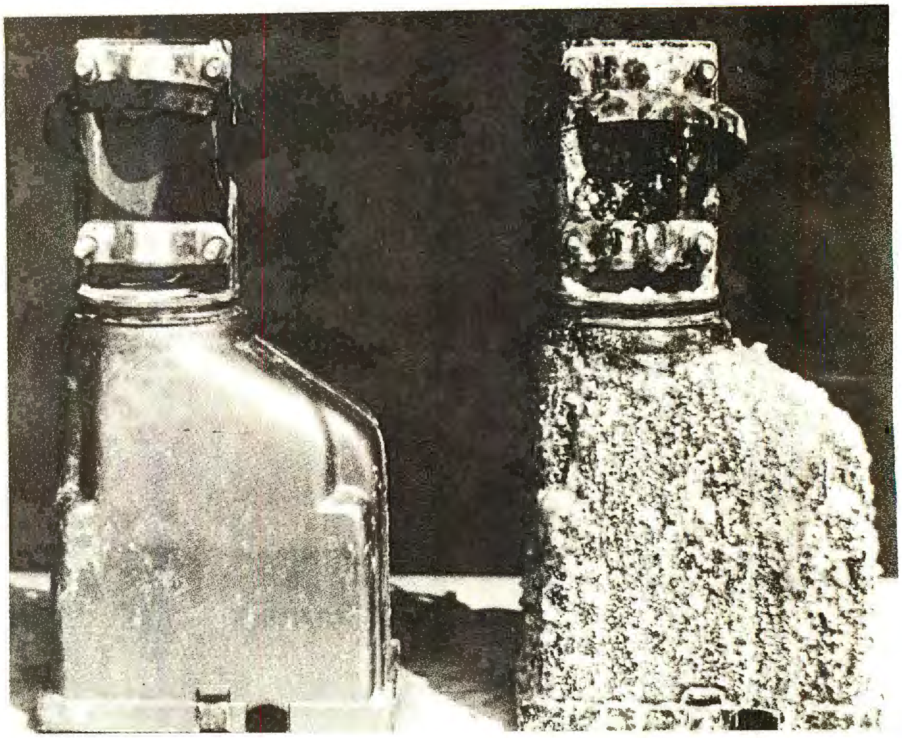


Photo shows effects of salt air (right) on rotator housing as opposed to rotator in normal atmospheric conditions (left).

Example of an in-line antenna rotator design. (Cornell-Dubilier Ham-II)

For most manufacturers, the only step up from a basic manual rotator system is to a fully automatic system. The fully automatic system has no pushbutton switches for the turn commands. Instead, the compass indicator becomes the antenna position selector. As you turn the selector knob to any position on the compass scale, the antenna rotates and automatically stops at the selected heading. Again, you can mark the dial for each channel or station that can be received in your area.

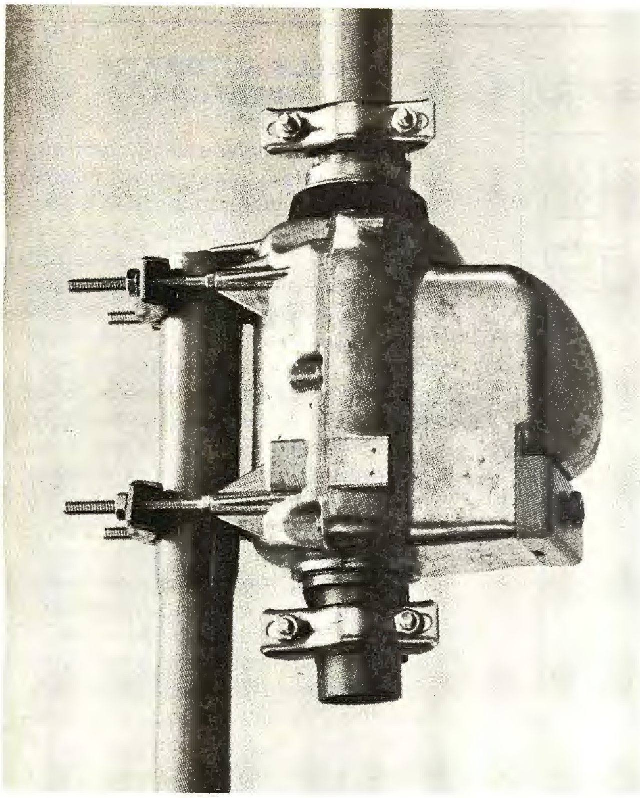
While all fully automatic systems offer a high order of operator convenience, Cornell-Dubilier's Model AR-33 deserves special mention. In addition to the standard compass-dial control, this system's controller has five pushbutton switches that allow the user to "key in" heading commands. Operation of any of the buttons relieves the user of having to turn the compass dial to select the direction for a given station. He just pushes the button, and the antenna automatically rotates to the heading which he had previously set in.

More About Automatics. You pay top dollar for a good automatic antenna rotator system, but with it you get more than just operational convenience. Materials and design considerations are top quality, and the accuracy of the system is greater. The latter is especially important if you happen to live in a deep-fringe reception area.

The less expensive automatic antenna rotator systems employ a small dc motor in the controller to turn the position indicator in unison with the drive motor at the antenna end. A cam-actuated switch in both the controller and antenna drive keeps the system in synchronization. However, because of electrical and mechanical tolerances, each control "step" requires from 3° to 6° of rotation. Since the system is electromechanically synchronized, it is possible for the motors to eventually move out of sequence.

The more expensive systems are totally electronic. The direction control

Blonder-Tongue SA-1000 manual rotator controller.



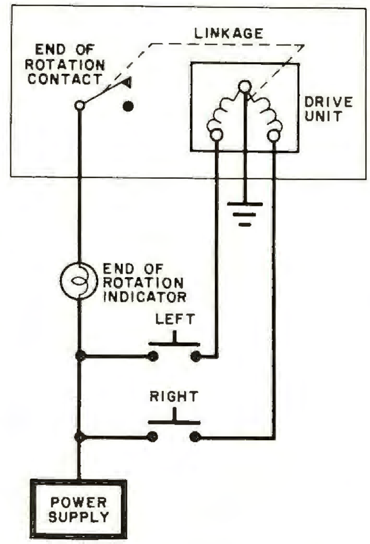
Radio Shack 15-1220 drive system is an example of the offset design.

in the controller forms half of a bridge circuit. The other half of the bridge is a disc potentiometer that is turned when the drive motor rotates the antenna; this pot is located in the drive unit. Turning the direction control unbalances the bridge, which then signals the drive unit to rotate the antenna until the bridge balances. When the bridge is balanced, antenna rotation ceases.

The elimination of mechanical elements in the all-electronic system brings the tolerance down to about 2° steps, providing as many as 60 more set points on the controller dial. Another extra of the all-electronic system is completely silent operation, except for the click of a relay at the end of rotation. Even the relay click is eliminated in Blonder-Tongue's Ultramatic system, which uses SCR's for the switching.

Drive Units. No matter which model you choose, from simple manual to top-of-the-line fully automatic, the drive unit in the rotator system is the weakest link. It does all the heavy work and is generally subjected to a wide range of weather conditions. The drive unit must be able to bear up under the mechanical stresses placed upon it by weight and loading factors, heat, cold, water, ice, and corrosive elements (usually salt) in the air. To beat the elements, manufacturers have devised quite reliable housing and sealing designs for their drive systems.

Inside the drive unit, a worm or spur (planetary) gearing system is used for the final power train between the motor and turning head to which the antenna is mounted. The spur gear has the greater efficiency, averaging about 80% to 90% as opposed to the 50% or so of the worm drive. This per-

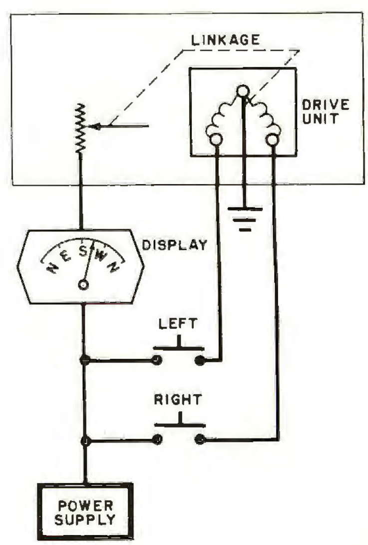


MANUAL ROTATOR

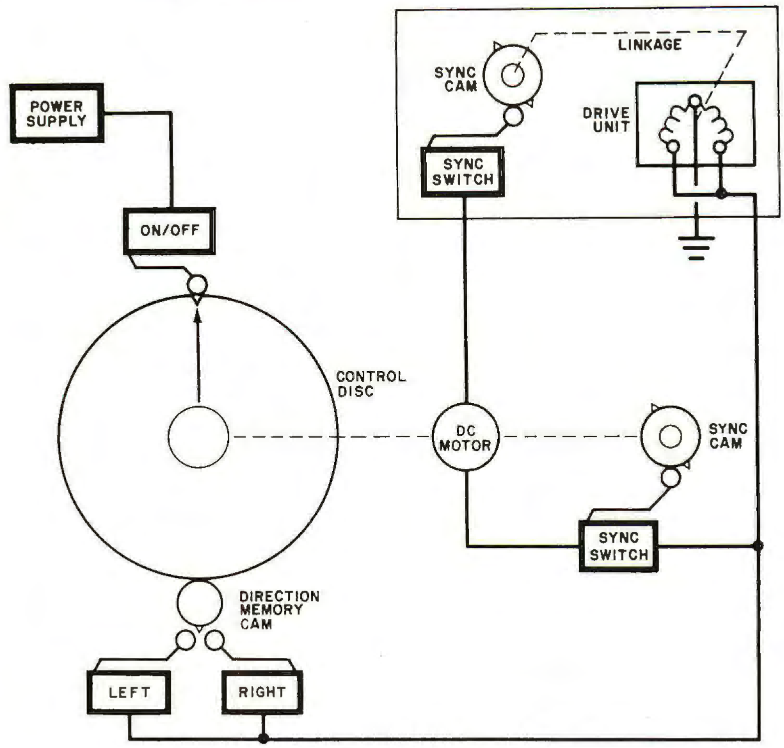
In a manual antenna rotator system, power is supplied to either the turn-right or the turn-left ac motor windings of the drive motor when the respective pushbutton is held in the closed position. Button contacts are mechanically locked out to prevent both from being closed simultaneously. Mechanical linkage between the drive motor and contact switch actuates an indicator light in the controller at the end of rotation.

SEMIAUTOMATIC ROTATOR

Operation of the metered semiautomatic antenna rotator is identical to that of the manual rotator. Mechanical linkage from the drive system, however, turns a potentiometer in the drive housing as the antenna rotates. The amount of current through the meter is proportional to the direction in which the antenna is pointing. Semiautomatic systems that use a revolving disc as an indicator are basically identical to fully automatic systems, except that the automatic-stop mechanism is not included.

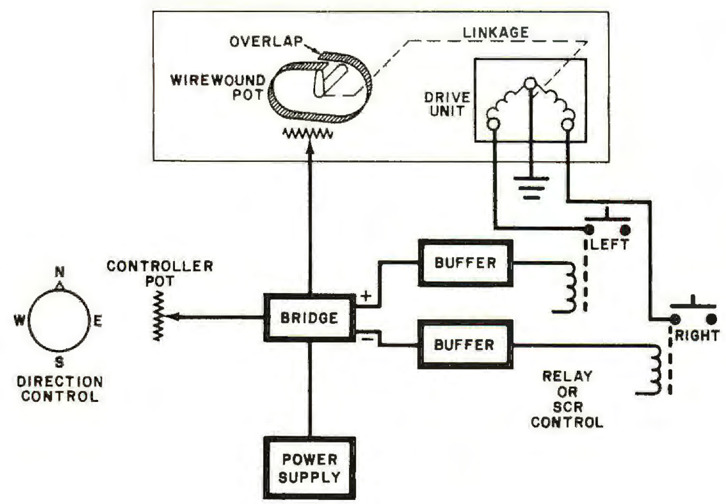


Alliance's T-45 controller uses meter indicator.



FULLY AUTOMATIC ROTATORS

As the control knob on a fully automatic antenna rotator system is turned, switches around the control disc are actuated. The power switch senses the change and turns on power to the system. The direction of change is mechanically sensed and stored by the memory cam. Power is supplied from the memory cam switches to the turn-left or the turn-right winding on the ac drive motor to rotate the antenna. Simultaneously, power is applied to the dc motor in the controller through the two sync switches that control the phase. The mechanical linkage in the drive turns the sync cam, actuating an internal sync switch. Inside the controller, a second sync cam and control disc and antenna position indicator are linked to the dc motor. Antenna position and indicator are kept synchronized by alternate action of the sync switches. The antenna rotates until the knob position and indicator agree. Power is then removed by the power switch and rotation stops.



ELECTRONIC-CONTROL AUTOMATIC ROTATOR

The direction control knob in an all-electronic controller makes up half of a bridge circuit. Once the control is turned, the bridge is offset from null, in a positive or a negative direction, depending on the direction in which the antenna is to be moved. The offset voltage is buffered and used to actuate a relay or SCR. Turn-left or turn-right power is sent to the respective winding of the drive motor, and the antenna begins to rotate. The mechanical linkage from the drive motor repositions the wiper of a wirewound potentiometer. (The ends of the pot overlap to provide full-rotation sensing.) The resistance of the drive-mounted pot is used as the other half of the bridge. When the resistance of the drive pot is the same as the controller pot, the bridge is balanced and the output is null. The relay then cuts out (or SCR turns off), removing power from the drive motor. A power indicator comes on while the antenna is rotating and shuts off when power is removed from the drive motor.

mits a higher starting torque for moving a heavy antenna and breaking through ice.

Although somewhat less efficient on start-up, the worm drive is better than the spur for stopping antenna rotation. The gear itself acts as a positive brake and is less prone to windmilling. However, unlike the spur, which uses the weight of the armature as a clutch, the worm drive can be stripped and permanently damaged if windmilling does occur.

In-line and offset drive arrangements are design considerations that depend primarily on the gearing system used in the drive unit's housing. It's simpler, for example, to package a worm drive in an offset arrangement than to try to use an in-line arrangement.

An offset system can usually be made more compact and lighter in weight than an in-line design. The result is less resistance to wind, since the top and bottom masts overlap to minimize the mounting area. However, the offset design lowers the center of gravity, placing more stress on the bottom mast. As a result, it is often necessary to lower the drive unit so that the additional strain is placed on the chimney or wall mounting brackets.

In-line arrangements evenly distribute antenna weight and wind stress

ANTENNA ROTATOR BUYER'S GUIDE

Manufacturer	Model No.	Type	Control Accuracy	Price	Remarks
Alliance	K-22	manual	N/A	$38.95	
	T-45	semi	5°	46.95	Meter direction indicator
	U-100	auto	10°	54.95	
	C-225	auto	3°	69.95	All-electronic control
Blonder-Tongue	SA-1000	manual	N/A	64.70	
	U-1000	auto	2°	86.60	All-electronic, SCR control
Channel Master	9513A	semi	4°	49.95	Available wired for 220 V ac
	9512A	auto	4°	59.95	Available wired for 220 V ac
Cornell-Dubilier	SA10L	manual	N/A	39.95	
	AR-20XL	auto	6°	49.95	
	AR-22XL	auto	6°	74.95	Heavy-duty version of AR-20XL
	AR-40	auto	3°	94.95	All-electronic control
	AR-33	auto	3°	114.95	All-electronic & preset controls
	CD-44	semi	2%	129.95	For ham and CB antennas up to 500 lb
	HAM-II	semi	2%	159.95	Same as CD-44 for antennas up to 1000 lb
Radio Shack (Realistic)	15-1223	auto	3°	39.95	Dial resettable for initial correction
	15-1220	auto	2°	49.95	All-electronic control
RCA	10W606	auto	3°	54.95	Dial resettable for initial correction
	10W707	auto	2°	64.95	All-electronic control

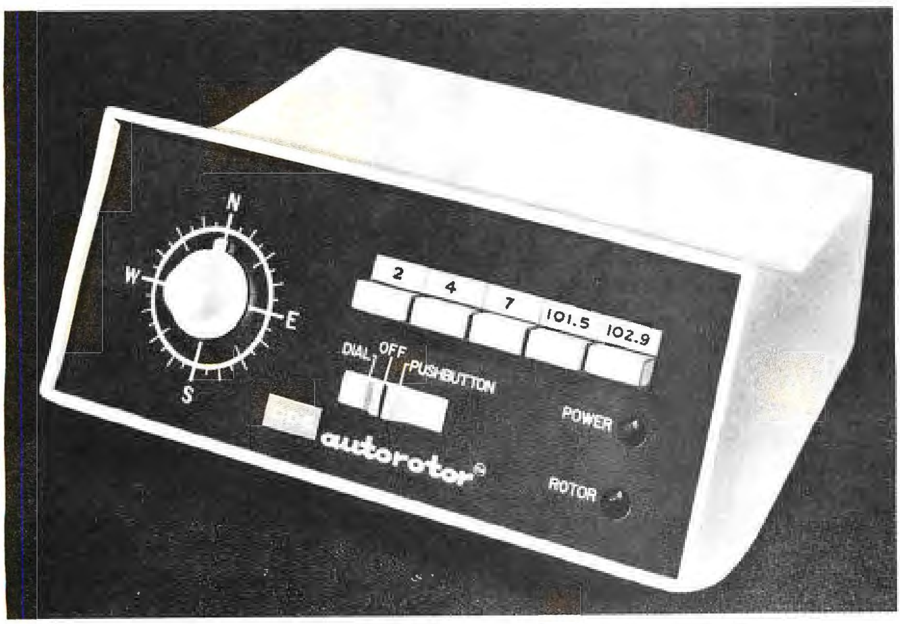
throughout the entire mounting assembly. The major disadvantage of the in-line arrangement is that it must be larger to accommodate the two masts end to end.

The overall strength of either type of arrangement depends on the quality of the materials used, which is generally quite high. Hence, strength need not be much of a concern for most conditions. Of course, where the wind and/or weight loading stresses are severe, special thrust-bearing brackets (turnable brackets that clamp to the masts) will give additional support.

The offset systems are more susceptible to problems when it comes to water and icing because the top of the drive mast must be open to accept the top mast. Special gasketing and mounting hardware inside the drive unit provide water sealing.

To move a massive antenna and break through ice, and also to provide reliable operation for a long time, most drive systems are equipped with high-torque drive motors. Within the first year, a rotator system's torque can decline by as much as 10%, due mainly to the loss of lubricant efficiency, hysteresis losses in the motor, and changes in the characterics of the starting capacitor in the controller. By providing a high initial torque rating for the drive motor, a longer useful life can be expected. Typically, you can expect 12 or more years of operation from today's antenna rotator systems.

If you live near the ocean, salt air will become your biggest enemy. There are few materials that will bear up to the corrosive action of salt and water. Even though new alloys of aluminum and zinc are being used in modern rotator drive systems, salt air is likely to reduce the life expectancy of the system by as much as 25%.



Cornell-Dubilier's AR-33 permits preprogramming for special channels. Unit is all electronic.

Installation Notes. For new antenna rotator installations, you'll have to plan on some extra-cost items, such as new masts, mounting brackets, and cable to connect the rotator's controller to the drive unit. These items are not usually included with the rotator system itself.

For runs up to 150′ (45.7m), 20-gauge cable will be sufficient. For longer runs, use 18-gauge or larger cable. Also, if you're considering extra drops for control from several stations not located in a single room, you'll have to add wall jacks and additional cable when making your purchases.

When installing the rotator system, leave at least 24″ (61 cm) of slack antenna cable to allow for the antenna's turning radius without interference. For initial alignment, check the drive housing for orientation marks.

The maximum heights of the top and bottom masts on the roof will depend on the type of rotator system and antenna you're using. To obtain greater antenna height than is recommended for your rotator/antenna setup, use extra guying and thrust bearings. However, before you take this step, check with your dealer to draw on his experiences with local wind and weather conditions.

According to most manufacturers, maintenance of antenna rotator systems is very easy—there's nothing to do. Actually, there is one thing you can do to extend the life of your rotator system — lubricate the drive unit periodically with the lubricant prescribed by the manufacturer. ◈

Amateur Radio Project

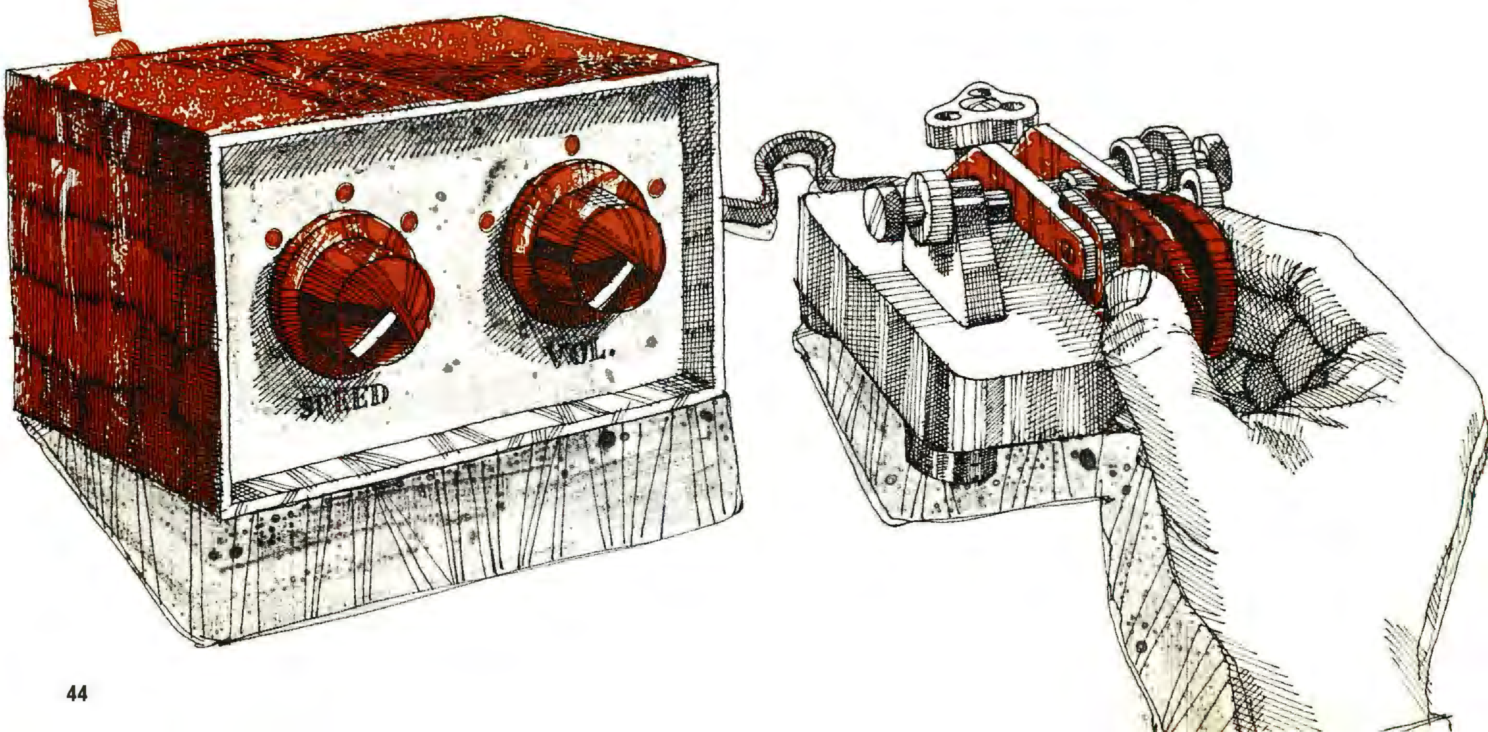
A Simple Electronic Keyer for Sending Morse Code

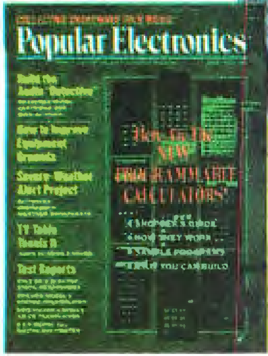
BY WILLIAM J. VANCURA, WB9OBB

ONE WAY for the CW radio operator to send almost perfect Morse code is to use an electronic keyer. Most commercially available keyers are relatively expensive, but it is easy to build a low-cost keyer using TTL devices and a pair of 555 timer IC's.

The keyer features a variable clock (speed) rate and a side-tone oscillator. It can be used to key a CW transmitter or as a CPO (code-practice oscillator). The circuit operates from any conventional 5-volt dc source. Since it draws only 40 mA of current, it can even be battery powered, providing many hours of operation from ordinary pen-lite (AA) cells.

Quad 2-input NAND gate *IC1*, as shown in the schematic diagram, eliminates most of the diodes commonly used in other keyer circuits and





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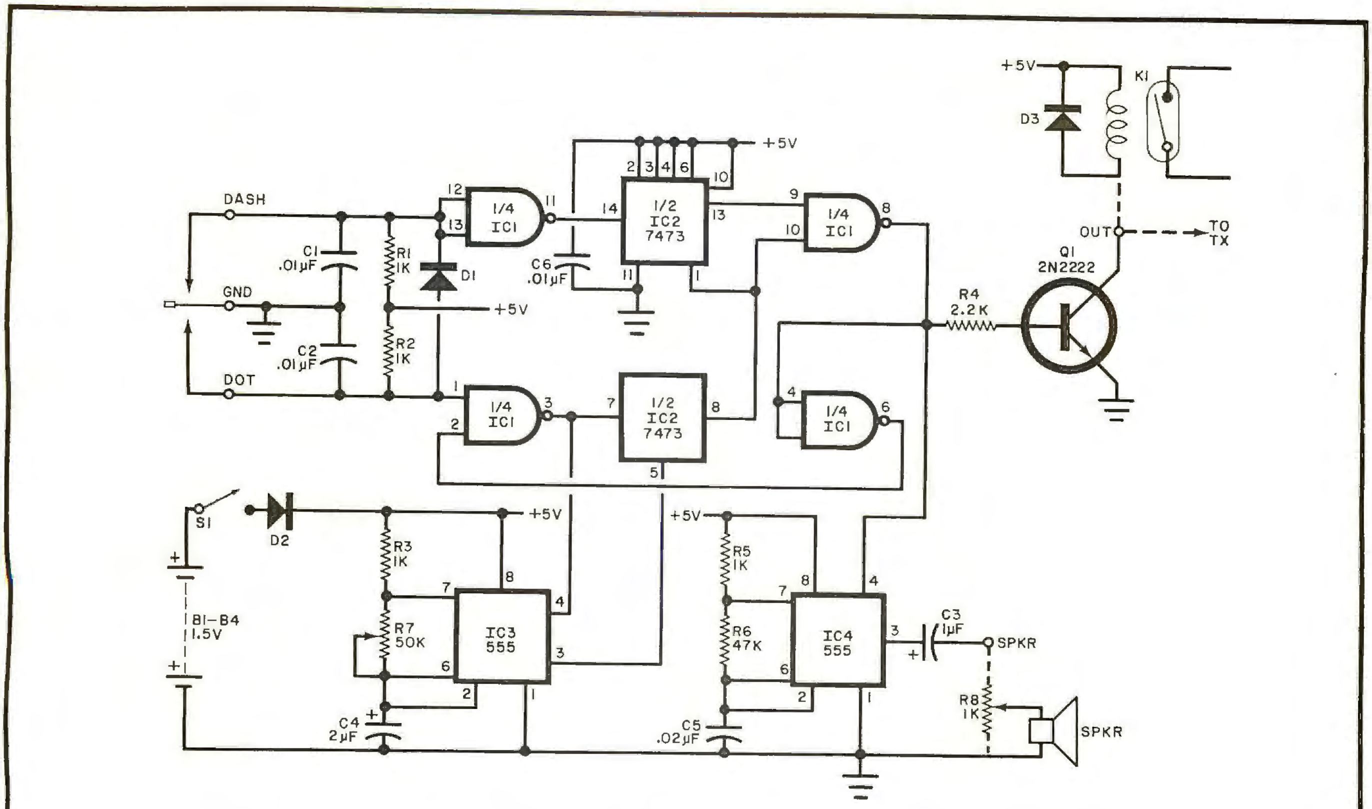


Relay circuit is for negative-grid keying, and slide-tone oscillator for code practice.

PARTS LIST

B1,B2,B3,B4—1.5-volt cell
C1,C2,C6—0.01-µF disc capacitor
C3—1-µF, 16-volt electrolytic capacitor
C4—2-µF, 16-volt electrolytic capacitor
C5—0.02-µF disc capacitor
D1,D2,D3—Silicon rectifier diode
IC1—7400 quad 2-input NAND gate IC
IC2—7473 dual flip-flop IC
IC3,IC4—555 timer IC (can be a dual-timer IC)
K1—Reed relay (Potter & Bromfield JR1000 or similiar)
Q1—2N2222 transistor
R1,R2,R3,R5—1000-ohm, ½-watt resistor
R4—2200-ohm, ½-watt resistor
R6—47,000-ohm, ½-watt resistor
R7—50,000-ohm, reverse-log taper potentiometer
R8—1000-ohm potentiometer
S1—Spst switch
SPKR—8-ohm speaker
Misc.—Perforated or printed circuit board; suitable metal chassis box; battery holder; control knob; paddle assembly; hookup wire; solder; machine hardware; etc.
Note: Etched and drilled printed circuit board available for $3.50 from: William Vancura, 4115 35 Ave., Moline, IL 61265

provides a TTL-level signal for the remainder of the circuit. Dual flip-flop *IC2* generates the dashes and dots in a 3:1 ratio, with the spaces being one-dot wide. Timer *IC3* serves as the system clock generator, with potentiometer *R7* acting as the speed control. Timer *IC4* generates an audio signal when gated, producing a side tone so that you can hear what you are sending.

Output transistor *Q1* is required if you intend to use the circuit to key a transmitter. If negative grid keying is desired, add reed relay *K1* to the circuit as shown. This relay isolates the keyer circuit from the voltages used in the transmitter.

The circuit can be assembled on a piece of perforated board, using a point-to-point wiring technique. Or you can design a printed circuit board. There is nothing critical about parts placement or lead routing.

If you prefer, you can substitute a dual-timer IC for the separate *IC3* and *IC4* timers shown. Speed-control potentiometer *R7*, which mounts on the front panel of the chassis box in which the keyer is to be housed, should have a reverse-log taper to improve linearity. The side-tone oscillator can be adjusted to produce a desired tone in the speaker.

If you plan to use the keyer with a transmitter, the circuit must be housed in a grounded metal chassis box to reduce the possibility of r-f interference. You can easily fabricate a paddle keyer. Mount it so that the contacts are inside the box, with the paddle arm exiting through a slot in the box. Make certain that the paddle arm moves freely, without contacting the metal chassis box.

After assembling the keyer, check out its operation in both the transmit and CPO modes. ◈

"You should listen more carefully, dear. Mother only called you a lazy CB."

IMPROVED GAS AND FUME DETECTOR

This high-sensitivity noxious-fume detector is for both home and mobile use.

BY C. R. LEWART

THE Taguchi Gas Sensor has made possible a number of gas and fire detectors (such as the "Poisoned Air Detector," POPULAR ELECTRONICS, February 1974). Now, there is an improved version of this very useful sensor that retains the high sensitivity, compact size, and low cost of its predecessor. The new sensor, however, has greater stability and an electrically isolated low-current 5-volt heater.

The new sensor is an ideal building block for inexpensive but very sensitive ac or dc gas alarms for the home, car, trailer, boat, etc. It also makes it possible to actually measure the gas concentration for mobile antipollution tuneups and for the detection of small gas leaks. Presented here are three ways in which you can put the new sensor to use.

Sensor Characteristics. The sensor consists of a piece of semiconductor material molded around a small filament heater. It is housed in a stainless-steel, wire-mesh-topped enclosure. The semiconductor material — mainly tin oxide (SnO_2) — is put through a sintering process during manufacture to increase the active area to be exposed to the air entering the sensor through the wire mesh cover.

When the semiconductor material is heated in the presence of combustible or oxygen-reducing gases or vapors, the material's resistance decreases. The sensor can respond to carbon monoxide, hydrogen, propane, gasoline, alcohol vapors, etc. A useful indication of the change in sensor conductivity can be obtained with gas concentrations as small as 50 to 100 ppm (parts/million) of carbon monoxide, propane, or methane.

The reactions that occur in the semiconductor material are reversible so that the sensor can be used to make thousands of measurements before having to be replaced. After an initial warmup of 2 to 5 minutes, the sensor responds within a few seconds to the presence or change in concentration of a combustible gas. Recovery time after being exposed to fresh air is 2 to 3 minutes.

About 1 volt greater than the nominal 5-volt operating potential is recommended for the initial warmup and to clean the sensor after exposure to a noxious gas. At the 5-volt operating potential, the sensor's heater draws 130 mA of current. Its resistance in fresh air is between 20,000 and 100,000 ohms.

Home Gas Alarm. The circuit illustrated in Fig. 1 is a line-powered gas detector for home use. Switch *S1* applies a potential of about 6 volts to the filament of gas detector *TGS* when in the CLEAN position and about 5 volts in the RUN position. Sensitivity is preset by placing *S1* in the RUN position and adjusting *R2* until the alarm sounds and then backing off on the adjustment until the alarm just cuts out. Repeat this procedure after a 5-minute warmup period.

You can now test the sensor by rubbing a drop of alcohol between your fingertips in the vicinity of the mesh-topped sensor. The alarm should sound. After the alarm has sounded, set *S1* to CLEAN for 2 minutes or so. Then adjust the sensitivity with *R2*.

To compensate for variations between gas sensors and SCR's, use a value between 1000 and 5000 ohms for *R5* so that potentiometer *R2*'s rotation is approximately three-quarters clockwise when the alarm triggers in fresh air. Of course, when performing tests and making sensitivity adjustments, do not wear after-shave lotion

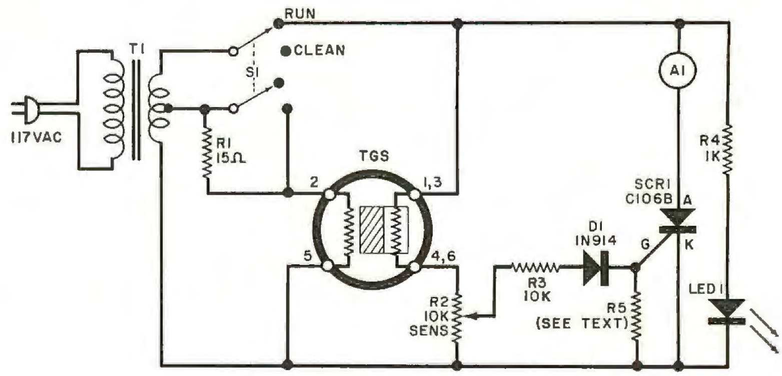


Fig. 1. Basic line-powered gas alarm causes SCR to fire passing current through a 12-volt bell, buzzer, or Sonalert.

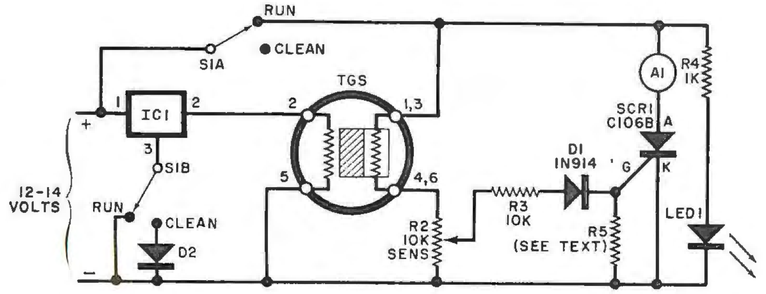


Fig. 2. Powered from a 12-volt dc source, this alarm is useful in trailers, campers, or boats. Operation is similar to home alarm.

(or perfume), or drink alcoholic beverages. If you do, the alarm will trigger falsely.

The entire circuit is simple enough to assemble with point-to-point wiring. Use a standard 7-pin vacuum-tube socket for the *TGS* gas sensor. The audible alarm device you use for *A1* should be rated as 12 volts and not exceed the rating of the SCR in its current demand. If you plan to use this circuit in a potentially explosive atmosphere, use a noncontact type alarm, such as the Mallory Sonalert®. Also, *R4* and *LED1* serve as a power-on indicator system, which can be eliminated from the circuit if you wish to economize.

Mobile Alarm. The circuit for a gas alarm system for car, boat, trailer, etc., is shown in Fig. 2. This circuit is similar to that shown in Fig. 1 except that it does not get its power from the 117-volt ac line. Regulator *IC1* compensates for variations in the vehicle's battery voltage that occur when the generator/alternator cuts in and out. If such variations reach the sensor's filament, changes can occur in the sensor's resistance. Diode *D2* increases the heater potential from the nominal 5-volt operating point to about 5.7 volts when *S1* is set to CLEAN.

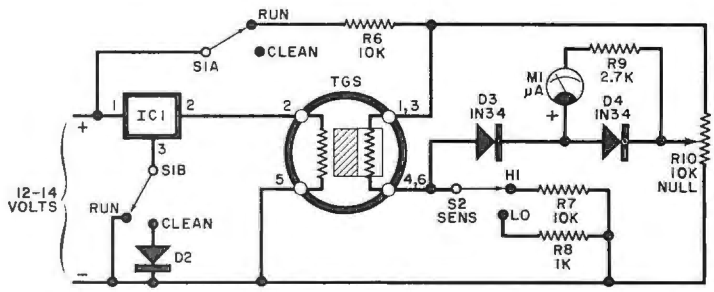


Fig. 3. This 12-volt dc detector uses a meter readout instead of alarm for quantitative leakage measurements and locations.

PARTS LIST

A1—12-volt signalling device (buzzer, Mallory Sonalert®, etc.)
D1—1N914 diode
D2—50-volt, 1-ampere silicon diode
D3,D4—1N34 germanium diode
IC1—5-volt regulator IC (Radio Shack No. 276-2770 or similar)
LED1—Any red light-emitting diode
M1—50-μA meter movement (Lafayette Radio No. 99R51146 or similar)
The following resistors are ½-watt, 10%:
R1—15 ohms
R3,R6,R7—10,000 ohms
R4,R8—1000 ohms
R5—See text
R9—2700 ohms
R2,R10—10,000-ohm linear-taper potentiometer
S1—Dpdt switch
S2—Spdt switch
SCR1—C106B silicon controlled rectifier (Radio Shack No. 276-1079 or similar)
T1—12.6-volt, 1-ampere center-tapped transformer
TGS—Model 812 Taguchi Gas Sensor (Available from Southwest Technical Products Corp., Dept. PE-1, 219 W. Rhapsody, San Antonio, TX 78216 at $6.95 each)
Misc.—Suitable enclosure; 7-pin tube socket for sensor; perforated board; machine hardware; hookup wire; solder; etc.

The value of *R5* should be selected in the same manner as for the home alarm. Unlike the home alarm system, the mobile system's alarm cannot be turned off via *R2* because of the dc flowing through the SCR unless *A1* is a mechanical buzzer that interrupts the current flow.

To operate the system, first place *S1* in the CLEAN position for 2 to 3 minutes. Then set the switch to RUN.

Turning *R2* down and flipping *S1* to CLEAN, and back to RUN, will turn the buzzer off.

Gas Measuring System. The circuit shown in Fig. 3 is particularly interesting because it provides a quantitative measurement of gas concentration, rather than the simple go/no-go indication of the previous circuits. This circuit can be used for any gas measurement from vehicular engine tuneups to gas-leak detection. In use, the meter's pointer swings up-scale by an amount proportional to the nearness to the source of the gas or concentration of gas.

The power supply for the gas measuring system is similar to that used in the mobile alarm circuit. The sensing element of *TGS* becomes one side of a bridge in this circuit, with the other sides consisting of *R7* or *R8* and both sides of potentiometer *R10*. The meter movement is connected across the bridge and *R10* adjusted for bridge balance (0 indication on the meter). When gas is introduced to the sensor, the resistance of *TGS* decreases, unbalancing the bridge. When this occurs, the meter pointer starts moving upscale by an amount directly proportional to the amount of unbalance in the bridge. Resistor *R6* limits the total current through the Taguchi Gas Sensor.

To operate the system, first set *S1* to CLEAN for 2 minutes, switch to RUN, set *S2* to the desired sensitivity range, and null the meter with *R10*. Accurate meter calibration requires specialized equipment, which your local service station might use to perform antipollution emissions checks.

The major problem with the sensor is that it does not differentiate between carbon monoxide and carbohydrates. However, comparing the exhaust readings of your vehicle's exhaust with those obtained with a commercial gas analyzer will give you reasonably good calibration.

In the gas measuring configuration, the gas sensor should be physically separated from the electronics package. Use a flexible four-conductor cable between sensor and electronic package.

When making measurements, you can set the detector to high sensitivity first and, if necessary, switch to the lower sensitivity range. Operated this way, the detector should be able to locate almost any gas leak along a complex arrangement of pipes. ◈

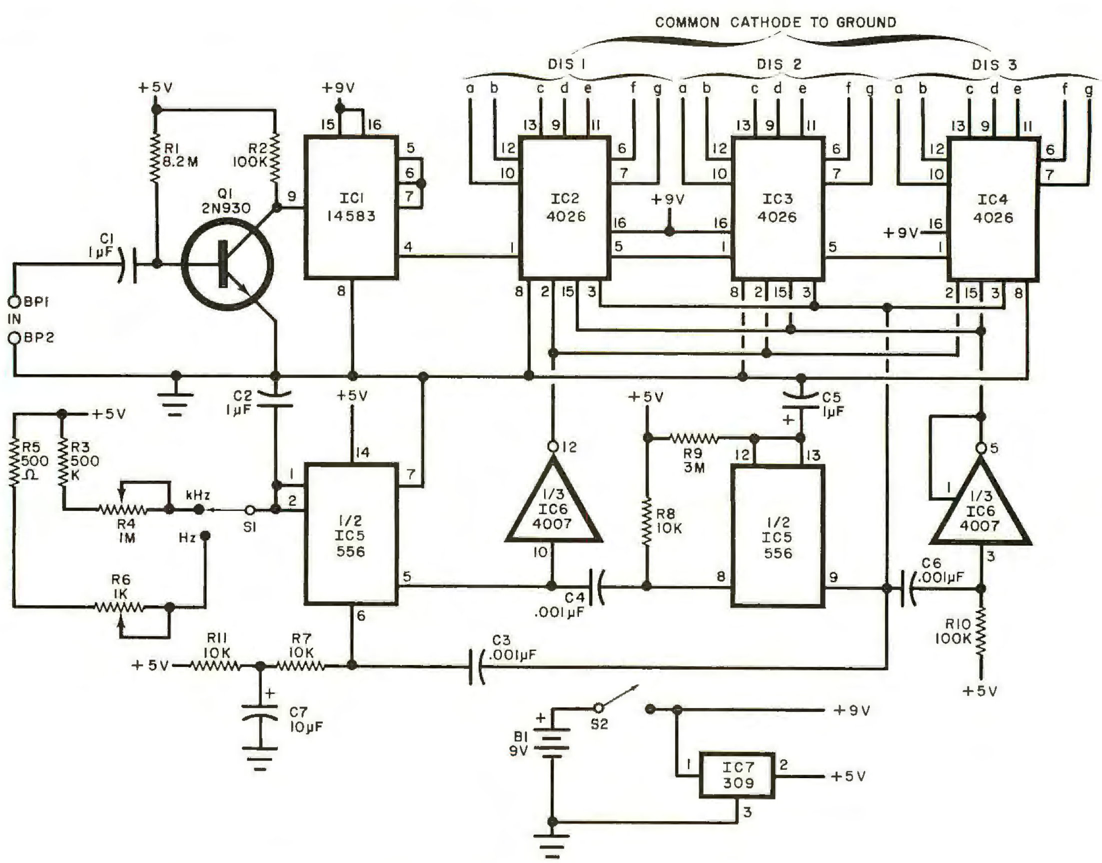
BUILD A LOW-COST
1-Hz to 1-MHz Frequency Counter

Sophisticated, low-cost counter with 3-digit readout uses state-of-art CMOS chips.

BY NORMAL P. HUFFNAGLE

A FREQUENCY counter can be as useful in working with electronic equipment as an oscilloscope, yet it is often the last piece of test gear the hobbyist and experimenter buys. The main reason for this save-for-last attitude stems from the fact that commercially made counters are relatively high priced. Now, however, the easy availability of inexpensive "surplus" IC's and low-current LED displays makes it possible for you to build a low-cost, three-digit frequency counter with a range from 1 Hz to about 1 MHz). By shopping carefully (see the ads at the back of this magazine), you should be able to build your frequency counter for just about \$25 to \$30.

Circuit Operation. A frequency counter consists of a wave shaper that should have a reasonably high input impedance and a series of decade counting units. The wave shaper "conditions" the input signal to give it the clean-edged waveform necessary to trigger the decade counting units. The outputs of the counters drive numeric displays. The entire operation is controlled by a time base that enables the counter for a precise period of time. During the enable in-



PARTS LIST

B1—9-volt alkaline battery
BP1,BP2—Binding post (one red, one black)
C1,C2,C5—1-µF ceramic, Mylar, or polystyrene capacitor
C3,C4,C6—0.001-µF disc capacitor
C7—10-µF, 16-V, electrolytic capacitor
DIS1 through DIS3—Common-cathode 7-segment LED display (Motorola HEK-5 or similar)
IC1—14583 Schmitt trigger IC
IC2,IC3,IC4—4026 decade counter IC
IC5—556 dual timer IC
IC6—4007 dual complementary pair and inverter IC
IC7—5-volt regulator IC (LM309 or similar)
Q1—2N930 or similar transistor
Following resistors are ¼ watt:
R1—8.2 megohms
R2,R10—100,000 ohms
R3—500,000 ohms
R5—500 ohms
R7,R8,R11—10,000 ohms
R9—3 megohms
R4—Subminiature 1-megohm potentiometer
R6—Subminiature 1000-ohm potentiometer
S1—Spdt switch
S2—Spst switch
Misc.—Perforated board; IC sockets (optional); battery holder; small Bakelite or plastic case; machine hardware; hookup wire; solder; etc.

terval, all events present at the input are counted and totalized. At the end of the count interval, the counts are stored and displayed. The counter is then inhibited from accumulating more counts until the display period ends. Then the frequency counter is reset and a new count cycle begins.

The complete circuit of the frequency counter is shown in the schematic. The input circuit can be modified according to the availability of components. Just keep in mind that the input should have a reasonably high impedance and that the input of the *IC2* decade counter should have a clean positive-going leading edge.

Integrated circuit *IC1* is a Schmitt trigger that conditions the input signal and converts it to logic levels suitable for the *IC2* through *IC4* counter chain. The tenth input count to *IC2*, at pin 1, generates a "carry" pulse at pin 5 to toggle *IC3*. At the instant the carry pulse is generated, *IC2* causes *DIS1* to display a 0, while *IC3* causes *DIS2* to display a 1. When a tenth input pulse is applied to the input of *IC3*, a carry pulse toggles *IC4* and *DIS2* displays a 0 and *DIS3* a 1. In this circuit, the carry output of *IC4* (pin 5) can be used to turn on the decimal point of *DIS1* to indicate an overrange condition.

The timing starts with half of the dual timer (*IC5*). Switch *S1* enables either a 1-s or a 1-ms timing interval. During this interval, the second half of *IC5* generates a 2- or 3-second display interval during which the counters are disconnected from the input and the display system is unblanked. At the end of the display, a reset pulse initiates the timing/counting interval.

Construction. Except for the input binding posts, switches, and displays, the entire circuit can be assembled on a piece of perforated board using point-to-point wiring. The only critical area of assembly is around *Q1* and the input of *IC1*, where high-frequency signals will be present. Mount *Q1* and *IC1* at the end of the board nearest where the input jacks will be mounted on the case.

The displays, switches, and input binding posts should mount on the front of the enclosure. Mount the displays side by side in a slot just large enough to accommodate them and cement them in place. Then mount the binding posts and switches and complete circuit wiring according to the schematic diagram.

Calibration. You can use any frequency counter of known accuracy and a signal generator to make all frequency adjustments. Simply set *S1* to the Hz position, drive the counter with some fairly low-frequency signal, and adjust the setting of *R6* for the correct indication. If you are using a highly accurate frequency counter to monitor the output of the signal generator, adjust *R6* so that the displayed numbers on both counters are the same. Repeat the procedure with a high-frequency signal.

If you do not have access to a highly accurate frequency counter, you can calibrate the dial of any audio signal generator using a 60-Hz source and Lissajous pattern (on an oscilloscope). Then use the outputs as a reasonably accurate signal source to calibrate the frequency counter.

If you have an older signal generator whose dial has a high degree of inaccuracy, you can build the low-cost frequency counter into it. Then you will always know at exactly what frequency the generator is operating.◈

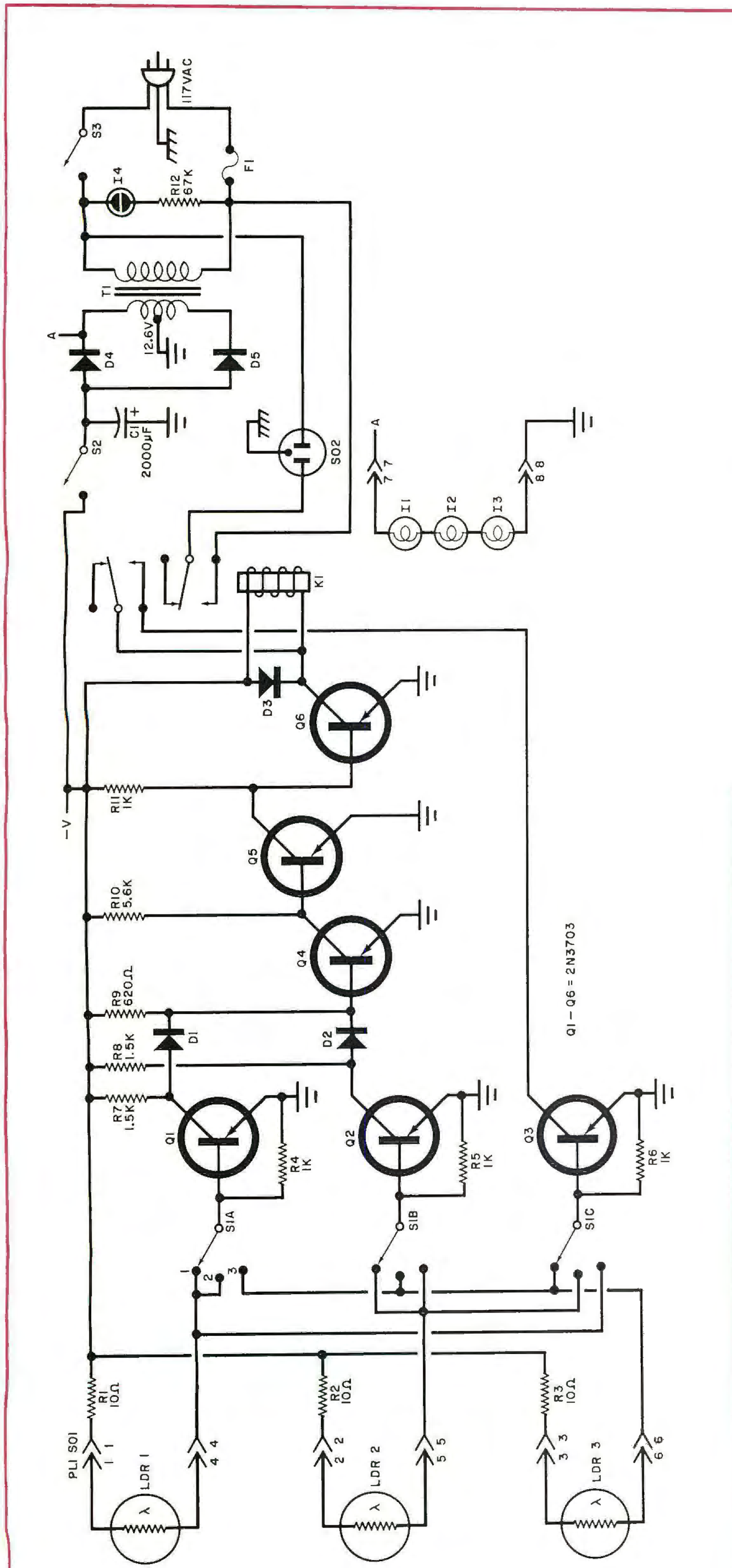
FLOWER POWER

Photocell, transistor-diode ac power control system

BY JIM SQUIRES

HERE is an electronic system which can be used to control up to 350 watts of ac power simply by varying the amount of light applied to a set of three photocells (light dependent resistors or LDR's). The latter can be mounted in any convenient location—in the case of the prototype, they were concealed in an arrangement of artificial flowers. (Hence the name, "Flower Power.") The system acts as a safety device to prevent the activation of a potentially hazardous appliance by young children. The illuminated flowers also provide a decorative control system which can function as a night light.

About the Circuit. In the project (see schematic diagram), pilot lamps *I1* through *I3* are attached to the bottoms of plastic flowers in line with light dependent resistors *LDR1* through *LDR3* mounted at the base of the arrangement. When an LDR is illuminated, its resistance is relatively low, on the order of a few hundred ohms. But when the LDR is placed in the dark or shade, its resistance goes up to a megohm or more. This in-



Light dependent resistors are energized by light from three lamps hidden among the flowers.

PARTS LIST

C1—2000-µF, 15-volt capacitor
D1,D2,D3—Germanium diode (1N56A, HEP R9134, or similar)
D4,D5—Silicon Diode (1N692, HEP R0052, or similar)
I1,I2,I3—#222 lensed incandescent lamp
I4—NE-2 neon lamp
K1—6-volt dc relay, 15-A contacts (Lafayette 30 27042 or similar)
LDR1—LDR3—Hobby-type photocell (Radio Shack No. 276-116 or similar)
Q1-Q6—Silicon pnp transistor (2N3703, HEP S0019, or similar)
PL1—Octal plug
All resistors ½W, 10%
R1,R2,R3—10-ohm resistor
R4,R5,R6,R11—1000-ohm resistor
R7,R8—1500-ohm resistor
R9—620-ohm resistor
R10—5600-ohm resistor
R12—67,000-ohm resistor
S1,S2—Spst toggle switches, 125-V, 3A
S3—4-pole, 3-position, non-shorting rotary switch
SO1—Octal socket
SO2—Three-conductor power receptacle
T1—12.6-volt center-tapped 1-A filament transformer
Misc.—Power cord; perforated board; metal utility box (5" x 4" x 3" or 12.7 cm x 10.2 cm x 7.6 cm); fuse holder; green stranded hookup wire; solder; press-on heat sinks; sheet aluminum wire; plastic flowers and leaves; silicone cement; vinyl tape; florist's crepe green stem tape; florist's wire; terminal strips; machine hardware; solder; etc.

crease in resistance is used to turn transistors on and off to control appliance power.

Three combinations of two illuminated LDR's and one shaded LDR are afforded by switch *S1*. With switch *S1* (the "Flower Selector" on the front panel) in position 1, shading *LDR1* and *LDR2* but not *LDR3* causes *Q1* and *Q2* to cut off, leaving only *Q3* conducting. Thus, the outputs (V_{CE}) of *Q1* and *Q2* are high. They are combined by diode AND gate *D1/D2* to produce a high input to the base of *Q4*. This transistor saturates, and its V_{CE} goes low, cutting off *Q5*. In turn, V_{CE} of *Q5* is high, and *Q6* energizes *K1*.

One set of the relay's contacts is wired across *Q6* through *Q3*. Since *LDR3* permits base current to flow, *Q3* saturates, keeping the bottom of *K1*'s coil at ground potential regardless of *Q6*'s state. Only by shading *LDR3* will the relay drop out, since *Q3* will cut off current through *K1*'s coil. Diode *D3* protects the switching transistors from the coil's inductive "kick".

The other set of *K1*'s contacts apply line voltage across power socket *SO2* when they close. Fuse *F1* should be chosen to fit the peak current demand, while neon lamp *I4* monitors the voltage on the fused side of the ac line.

The switching and lighting circuits

derive their power from a supply consisting of *T1*, and the full-wave rectifier/filter circuit made up of *D4*, *D5*, and *C1*. When only night light or TV light operation is desired, ac power switch *S3* should be closed and dc switch *S2* left open.

As mentioned earlier, three combinations are possible. Two LDR's, when momentarily shaded, turn the appliance on, while the remaining one cuts off *Q3* when its surface is shaded. This deenergizes *K1* and removes line voltage from *SO2*, turning the appliance off. The proper grouping for positions of FLOWER SELECTOR switch *S1* follow:

S1	FLOWER 1	FLOWER 2	FLOWER 3
1	ON	ON	OFF
2	ON	OFF	ON
3	OFF	ON	ON

That is, shading the LDR's below flowers 1 and 2 will turn the appliance on when *S1* is set to position 1. Shading the LDR below flower 3 will turn it off. The two other positions dictate similar patterns — but note that both on LDR's *must* be shaded simultaneously. Another safety feature is the protection given the appliance from power surges after a power failure.

If the project is supplying ac line current to an appliance when power fails, it keeps the load isolated from the line even after power has returned. In such a case it will be necessary to go through the correct shading procedure to restore power to the appliance.

Construction. Flower Power is composed of two units — the power board and the flower assembly. Most of the components are mounted on the power board. Only the switches, LDR's and lamps are off the board.

Since the circuit is relatively simple, it can be wired on a piece of perforated board. For safety purposes, the board should be mounted inside a metal utility box. The box can be concealed inside a clay flower pot for a more aesthetic appearance. Mount two sockets on the utility box. Octal socket *SO1* provides dc power for the LDR's and ac power for *I1*, *I2*, and *I3*. Socket *SO2* is a standard three-conductor power receptacle, into which the appliance should be plugged.

You will probably find that *Q3* and/or *Q6* get a bit hot in continuous operation. If desired, use press-on heat sinks. Allow clearance when mounting the board in a metal box for the leads from *F1*, *T1*, and the neon bulb *I4*.

Form three support flanges from sheet aluminum about 10" (25.4 cm) long to begin the flower assembly. Drill a ¼" (6.35 mm) hole at the straight end of each flange, and form a y-shaped base by securing the flanges with machine hardware. Also bolt three lengths of aluminum wire, such as used for clothesline to this point. Mount a cluster of plastic leaves on each flange and cement an LDR (avoid shorts) to the center of each cluster. Then remove the wire stem from each of three plastic flowers and slide the piece onto the aluminum wires to form a three-flower arrangement.

Solder a 36" (1-m) length of green stranded hookup wire to each contact of three #222 lensed lamps and LDR's. Then, with a small bead of silicone cement, mount a lamp at the *bottom* center of each flower. Wrap a layer of vinyl tape around the base of each lamp and LDR lead.

Next, route the wire pairs along the stems, wrapping them securely with florist's crepe stem tape (green) to the stems. Tie all wires into a neat bundle at the base of the arrangement. Cut the free ends of the wire bundle flush and prepare for soldering. Identify the leads using an ohmeter across the LDR's and a 6-volt battery across the lamps and connect and solder the appropriate leads to an octal plug (*PL1*). Be sure to secure the bundle every few inches with florist's wire. Finally, bend the stems so the lamps are directly over and about 2" to 5" (5.1 to 12.7 cm) above the LDR's.

Testing. Double check all wiring and physical assembly. If everything looks OK, insert *PL1* into *SO1* and turn on ac power switch *S3*. All lamps including *I4* should glow. Follow this by closing dc power switch *S2*, and place FLOWER SELECTOR switch *S1* in position 1. Shade *LDR1* and *LDR2* — you should hear the relay click as it latches on. Then shade *LDR3* — you should hear another click as the relay deenergizes.

Now, plug a lamp into power receptacle *SO2*. Repeat the shading procedure. The lamp should turn on and off in step with the relay. Open *S2* and check each of the three combinations. As a rule, open *S2* before changing the combination or opening *S3* (when turning the system off) and close *S3* before *S2* when activating the system. And remember — *please* don't water the flowers! ◈

DX PROGRAMS AND DX CLUBS ON SHORTWAVE

BY RICHARD E. WOOD

IF YOU'RE a shortwave listener, perhaps you're a member of a local, national or international DX club which sends you a magazine or club bulletin once a month or better. The volunteer clubs are fine sources of information, ideal places to exchange reception tips and get to know other SWL's.

There's another type of club, however, which is also a useful source of timely information on the fast-changing shortwave broadcast bands. This is the DX club organized by a shortwave broadcast station. Many other stations, though they don't have clubs, do broadcast regular DX programs. In fact, only a few stations beaming daily to North America don't have any kind of club or DX program. (Radios Peking and Tirana and RAE Buenos Aires are three of the latter.)

Why should a big international broadcaster organize a club, and even transmit news about other stations with whose ideology it may disagree? Probably in order to try to catch that elusive character, the DX station hunter, and turn him into a regular listener. One way to do this is by offering DX tips. Another way is by challenging him to hear and report the same station several different ways. Radio RSA, Johannesburg, for instance, offers prizes for reporting reception in every shortwave band it is using. The BBC World Radio Club occasionally challenges members to hear all its SW transmitting sites—rather an easy task, in most parts of the U.S.

Let's look at the twenty best DX and club programs that you can hear in English, and what they have to offer. We'll take them in rough order of popularity and usefulness aas seen from here, though tastes may differ. Remember that times are in GMT, but dates refer to *your* local date; the GMT date will be the next day, from 0000 to 0600. The times are approximate. Except for one airing from Radio Nederland Bonaire, and the show from Budapest, the DX program is never the first item in a transmission, but follows the news and/or other features. So tune in a few minutes early, and watch for reshuffles and possible changes of date and time. Frequencies are for summer 1976. For changes in September, consult the regular listings of English-Language Shortwave Broadcasts to North America in POPULAR ELECTRONICS for that month.

1. "DX Juke Box," Radio Nederland. Dick Speekman is the host for this lively Thursday show. Its varied contents and bright musical items give it its "Juke Box" format. In between the records you'll find both DX tips and technical info, with an average of five minutes of straight DX tips

taped by experienced, competent DX'ers in four continents: North America (U.S.A.), Europe (Sweden), the Pacific (New Zealand) and Asia (Sri Lanka). The New Zealand contributor is the well-known blind DX'er Arthur Cushen, and the tips are the same as those on his "DX World" show heard a month earlier direct over Radio New Zealand. Much of the news from the four is taken from recent top loggings by active DX club members in their continent, and credited to them by name. Dictation-speed reading of frequencies makes it easy to make notes which can then lead to useful "catches." The DX Juke Box also commissions staff members and others to write and record valuable technical courses for study by listeners, with scripts or study guides often available free from Hilversum. Topics covered from season to season include propagation and the radio spectrum, transistor technology, DX'ing techniques and similar topics. The Juke Box is a pleasant, professional program with something for every listener.

THURSDAYS

Time, GMT	Freq., MHz
0645-0720	11.73 (via Bonaire)
0815-0850	9.715 (via Bonaire)
2015-2050	11.73 (via Talata)
2145-2220	9.715, 11.73
0215-0250	6.165 (via Bonaire)
0500-0535	6.165, 9.715 (via Bonaire)

2. "Sweden Calling DX-ers," Radio Sweden. Arne Skoog is the founder of this long-running show, whose 1361st issue was on the air as this was written. Arne himself compiles many of the programs; others are handled by experienced DX'er Bengt Dalhammar. Every two weeks, Radio Sweden generously airmails a transcript of the tips selected for broadcast. Single issues are sent to contributors of tips used, while DX editors, DX clubs and regular contributors receive bulletins by mail regularly. It is doubly useful to those who receive it because Radio Sweden's reception in North America at the convenient evening listening hours is often poor and the transcript contains tips not broadcast on the air in English, but only in other language editions such as Spanish or Russian. A word of caution: Arne believes in DX democracy, and often carries tips from beginners, those without accurate frequency calibration or those unable to distinguish Spanish from Portuguese. It's still a useful show, 90 percent tips, the rest club news such as club-organized station popularity polls.

TUESDAYS

Time, GMT	Freq., MHz
1248-1258	15.305
1418-1428	15.305
2318-2328	6.035, 9.605, 11.705 (subject to change)
0248-0258	9.695, 11.705

3. "World Radio Club," BBC. Here we come to the first DX program in our list which adopts the club format. The club issues membership cards, but there are no obligations or qualifications. The atmosphere is chatty, sociable and far from highbrow. As for the contents, let's quote from the BBC's magazine, *London Calling:* "Information for shortwave enthusiasts in language acceptable also for the non-technically minded. Membership is open to all who write to World Radio Club, BBC World Service, Bush House, London." Like *DX Juke Box*, but unlike *Sweden Calling*, the Club program has a mixed bag of contents, with a few DX tips (often meaty ones, mostly from the BBC Monitoring Service at Caversham Park), and technical questions answered in very elementary language mostly by the BBC's mellow-voiced chief engineer, Henry Hatch. He generally selects the type of question asked by beginners. A recent example: "Why do I hear the same BBC program on 15.07 and 15.26 MHz but with a few seconds' discrepancy in time of arrival of each, so that, if I switch quickly between the two frequencies, I hear the same words or musical notes over again?" Henry's answer to that one, by the way, was that, while 15.07 comes direct from England, 15.26 is the Ascension Island relay. Programs of music and other non-urgent material are shipped by air from the London studios to Ascension, to be played at pre-designated times, theoretically synchronized with the London studio. But human lapses and technical factors (different lengths of tape leader, for example) can cause less-than-perfect synchronization, hence the double broadcast effect.

WEDNESDAYS

Time, GMT	Freq., MHz
1330-1345	9.74, 11.75 (via Tebrau), 12.095, 15.07 15.40 (via Ascension), 17.79
2315-2330	5.975, 6.175 (via Sackville), 7,325, 9.41 9.51 (via Sackville), 9.58 (via Ascension), 11.75, 11.78, 15.07, 15.26
FRIDAYS	
2100-2115	9.41, 9.58 (via Ascension), 11.75, 12.095, 15.07, 15.26
SUNDAYS	
0815-0830	9.60 (via Ascension), 9.64, 11.86 (via Ascension), 11.955, 15.07, 15.40 (via Ascension)

4. "Swiss Shortwave Merry-Go-Round," SBC. "The Two Bobs," Bob Thomann and Bob Zanotti, are the hosts. They are amateurs, and this is the first show in our list with mostly ham tips: ARRL competitions, DX'peditions, and rare countries now active. They play a tape each time with a "mysterious signal," and identify it, helping all-band listeners identify telemetry, LORAN, jamming, SSB, numbers stations, and other transmission modes. They answer technical questions, but not being broadcast DX'ers they simply do not know the SWBC bands and therefore may give misleading or wrong answers to questions. For instance, they recently gave an inquiring listener the schedule and name information on the "ORTF," Paris, oblivious to the fact that the station and the broadcast which they cited no longer exist. Unlike some DX programs which tend to be bland, the Two Bobs are firm in their views and pull no punches in their comments on such practices as DX'ing for country totals rather than program content.

2nd & 4th SATURDAYS

Time, GMT	Freq., MHz
1322-1345	15.14
2107-2130	9.59, 11.72, 11.87 15.305
0152-0215	5.965, 6.135, 9.725, 11.715
0437-0500	9.725, 11.715

5. "DX-ers Calling" and "Club Forum," Radio Australia. The oldest DX program today dates from 1946. Like "DX Juke Box," it has alternating compilers of DX tips, from the west, south and east coasts of Australia. Like "Sweden Calling," it dictates DX tips clearly, giving the name and location of reporters. Some tips are fresh and original; others are taken from published sources, hence not so timely.

SATURDAYS

Time, GMT	Freq., MHz
2130-2140	11.84, 11.93, 15.16

SUNDAYS

0900-0910	9.57, 15.27
1200-1210	9.58
1530-1540	9.77, 11.81
0215-0225	15.32, 17.795

"Club Forum" is the program of the Radio Australia Listeners' Club. To qualify for membership, you must send in twelve numbered reception reports at a rate of two per month over a period of six months. Members get a kangaroo lapel badge and membership certificate. Send to Listeners' Club, Radio Australia, Melbourne 3000, Australia; or to 1270 Ave. of the Americas, Suite 2708, New York, NY 10020. The "Forum" discusses club activities, welcomes new members, discusses the writing of reception reports, and generally provides a social hour for the members scattered around the world.

SATURDAYS

Time, GMT	Freq., MHz
0830-0845	9.57, 15.27
1200-1215	9.58
1230-1245	5.995, 6.005, 9.77, 11.81
1645-1700	9.77, 11.81
0215-0230	15.32, 17.795

6. "DX Corner," Radio RSA. Gerry Wood of Capetown is the presenter of this recently expanded show, now with two different editions weekly. Unlike the other DX programs offered more than once a week, "DX Corner" is written and presented with two distinct audiences in mind. The Saturday show is for the advanced DX'er, and the Wednesday offering is for the beginner and general listener. It's a little like "DX Juke Box:" there are regular courses on basic topics like shortwave receiver selection. DX tips emphasize stations in Africa, and there are spotlights on particular African stations. Like BBC's "World Radio Club," Radio RSA often talks about its own transmitting facilities at the H.F. Verwoerd station, now under expansion.

WEDNESDAYS & SATURDAYS

Time, GMT	Freq., MHz
1635-1645	11.90, 15.175
2135-2145	5.98, 7.27, 11.90
2305-2315	5.98, 9.585, 9.695, 11.90

7. "DX Party Line," HCJB Quito. Clayton Howard, the host, is sometimes joined by his wife Helen for three different slow-paced, rather rambling half-hours. The "Party Line" is just the opposite of the rapid-fire tips programs from Sweden, Australia and Japan. Clayton takes his time, mander-

ing through tips, Andean folk music, letters from listeners, taped interval signals, complete articles read out from DX papers, and "Tips for Real Living," a series of evangelical spots intermingled with the DX. The American Short Wave Listeners' Club is the main source of the tips, but HCJB has its own DX club, ANDEX, similar to those described above. Write to ANDEX, c/o HCJB, Box 691, Quito Ecuador. The editor of another club bulletin, John Trautschold, tapes a weekly report. Despite the three weekly editions, the "Party Line" is not particularly timely in its reporting. Some listeners will like its folksy atmosphere, others may be turned off by its slow pace, lack of original material, or mixture of religion and music with the DX. Reception quality is great, though.

Time, GMT	Freq., MHz
MONDAYS	
0930-1000	6.13, 9.745
1930-2000	15.30, 17.73, 17.855
0230-0300	6.095, 9.56, 11.915
WEDNESDAYS	
0230-0300	6.095, 9.56, 11.915
THURSDAYS	
0930-1000	6.13, 9.745
1930-2000	15.30, 17.73, 17.855
SATURDAYS	
0930-1000	6.13, 9.745
1930-2000	15.30, 17.73, 17.855
0230-0300	6.095, 9.56, 11.915

8. "Arthur Cushen's DX World," Radio New Zealand. Perhaps the world's best-known DX'er, blind-but-active Arthur, tapes his tips and station recordings at the Invercargill studios of the NZBC, near the tip of the South Island. This show is also for medium-wave DX'ers, especially those interested in Pacific and Southeast Asian stations. Radio New Zealand does not broadcast to North America, and its power is modest, but it is heard by nightowls even on the East Coast. You will hear Arthur's tips on other stations, however, especially Radio Nederland, Radio Australia and HCJB, a little later. This is the only monthly DX program.

Time, GMT	Freq., MHz
1st WEDNESDAYS	
0745-0800	6.08 (alternate 6.105), 9.54
1030-1045	6.08, 9.52

(both one hour earlier Nov.-Apr.)

9. "World DX News," Adventist World Radio. Many U.S. SWL's may never have heard this DX show, yet it is a good one, and audible in the U.S., except the West. Reason for its lack of fame here is that it is not broadcast to this continent, and that its schedule and single frequency are subject to change without notice. Like HCJB, Adventist World Radio, also known as the Voice of Hope, is a religious broadcaster. The show is prepared by British DX'ers, mostly from the World DX Club. All tips are original, not quoted from other programs or bulletins. It is transmitted over both stations from which AWR leases time in southern Europe. Better reception here is from the Malta transmitter, which is used later in the day for broadcasts to North America by Deutsche Welle.

Time, GMT	Freq., MHz
SATURDAYS	
2020-2045	6.035 (subject to change, via Malta)
SUNDAYS	
0935-1000	9.67 (via Sines, Portugal)

10. "Calling DX-ers & Radio Amateurs," Radio Budapest. Another club program, this show carries reports from members of the Radio Budapest Shortwave Club (write simply to Radio Budapest, Hungary). As a so-called "liberal" communist country in its internal policies, Hungary does not shrink from broadcasting news of western stations, even from countries like Spain or South Africa, or from the Vatican Radio or HCJB. But the quality of hobbyist tips varies. Some are outdated, others seem dubious. At times there are letter sessions, and at others, amateur tips, as the title imples.

Time, GMT	Freq., MHz
TUESDAYS & FRIDAYS	
0400-0415	6.00, 6.115, 9.585, 11.91, 15.22

11. "For the DX-ers" & "DX News," Voice of Turkey. Since Ankara extended its English transmission time last year it has had, like HCJB, a good deal of broadcast time to fill with, among other things, DX information. The idea of a daily DX program is a good one, but a challenge, of course, to obtain fresh timely material in sufficient quantity. Though Voice of Turkey tries, it does not really succeed in using the weekday five minutes valuably. Likewise, the longer Saturday show simply doesn't have the sources for good, original material, and keeps on repeating the same information, on domestic stations in Turkey, VoT QSL cards and the like. Like HCJB and others, it uses the DX show as a mailbag, reading out letters and reception reports. Ankara's show is not specifically beamed to the U.S., but reception is often good here.

Time, GMT	Freq., MHz
MONDAYS THRU FRIDAYS	
2230-2235	9.515, 11.88
SATURDAYS	
2215-2235	9.515, 11.88

12. "Calling All Listeners," IBA. Not a full-fledged DX program, but a mixture of listeners' mailbag and features on radio-related topics. Recent programs have covered such areas as IBA frequency selection and why the frequency of 11.645 MHz, received by a listener in Texas during the 2000 GMT English show in the summer, is not even used in winter; interviews with personnel from Galei Tsahal, the Israel Defense Forces' station whose one-kilowatt transmitter on 2.442 MHz is an exceedingly difficult catch for North American SWL's; a talk about the Israeli manufacture of television receivers, and so on. Announcer Ben Dalfen is a professional who uses his five minutes to the full. It's interesting, but there are no DX tips.

Time, GMT	Freq., MHz
SUNDAYS	
2250-2255	7.412, 9.82, 11.645 12.025

13. "DX Program," Radio Moscow. Moscow prefers to concentrate on amateur tips and short technical talks. Of course, even a listing of timely tips for Soviet domestic shortwave transmitters would be welcomed by the many U.S. SWL's who have chosen the challenging area of Soviet Union DX'ing as their specialty. They would all love to have authoritative information from Moscow on the identity of the Soviet transmitter sites in use and how to get QSL's for each of them; but that, too, is the last thing to expect on the "DX Program." Don't even hold your breath waiting for Radio Moscow to list its frequencies for the North American Service without truncating the last digit, rendering 9.685 MHz as "9.68."

Time, GMT	Freq., MHz
THURSDAYS	
2320-2330	5.905, 7.10, 7.11, 7.33, 9.635, 9.665, 9.685, 11.72, 11.75, 11.87, 12.00, 12.05,

	15.21, 15.245, 17.72, 17.76, 17.90
0320-0330	5.905, 7.33, 9.53, 9.665, 9.685, 9.70 (via Sofia)
0350-0400	6.02, 9.635, 11.96, 12.05, 15.13, 15.18, 15.21, 15.245, 17.72
0520-0530	6.02, 9.635, 9.71, 11.96, 12.05, 15.10, 15.13, 15.18, 15.21

14. "Finn DX," Radio Finland. Presented by the Friendly DX Club, "Finn DX" is produced by several experienced DX'ers, including Jyrki K. Talvitie, translator of this writer's book *Short Wave Voices of the World*, into its Finnish version. It is a lively mixed bag of station news, features, talks on DX techniques and progagation, reports on DX'peditions to remote receiving locations and remote stations, and straight DX tips. Drawbacks are at times rather heavily accented English and reception is variable (often poor in winter). There is interesting material on European commercial pirate and "hobby pirate" stations and on transpolar reception of North American domestic AM stations in northern Scandinavia.

TUESDAYS

Time, GMT	Freq., MHz
1413-1428	15.185 (alternate 15.11)
2313-2328	15.185

15. "DX Program," Radio Prague. Like the other communist stations, except Budapest, listening to foreign stations today makes Prague jittery; so you'll hear mostly amateur material and features on the Czechoslovak Radio's domestic services.

THURSDAYS

Time, GMT	Freq., MHz
0140-0150	5.93, 7.345, 9.54, 9.74, 11.99
0340-0350	5.93, 7.345, 9.54, 9.74, 11.99

16. "DX Special," Trans-World Radio, Bonaire. Al Stewart's TWR show resembles Clayton Howard's from HCJB in its mixture of DX and evangelism. Its items about DX clubs and tips are of varying degrees of difficulty. Best feature is the language identification quiz. Also broadcast from TWR Monaco.

WEDNESDAYS

Time, GMT	Freq., MHz
0045-0100	11.925

SATURDAYS

1207-1222	11.815

17. "DX Program," Radio Bucharest. DX tips mostly from Rumanian listeners, and rather routine loggings. Combined with technical questions from listeners, it's rather dull listening. Reception tends to be poor in the West, especially in winter. Some frequencies in use are never readable, so only the better bets are listed.

WEDNESDAYS

Time, GMT	Freq., MHz
0215-0227	5.99, 6.19, 9.57, 11.94
0415-0427	5.99, 6.19, 9.57, 11.94

18. "DX Program," Radio Sofia. Compiled by the national amateur radio club of Bulgaria, this show gives details of contests, rare DX amateurs active, etc. Dull presentation, little for the SWL.

FRIDAYS

Time, GMT	Freq., MHz
0015-0025	9.70
0415-0435	9.70

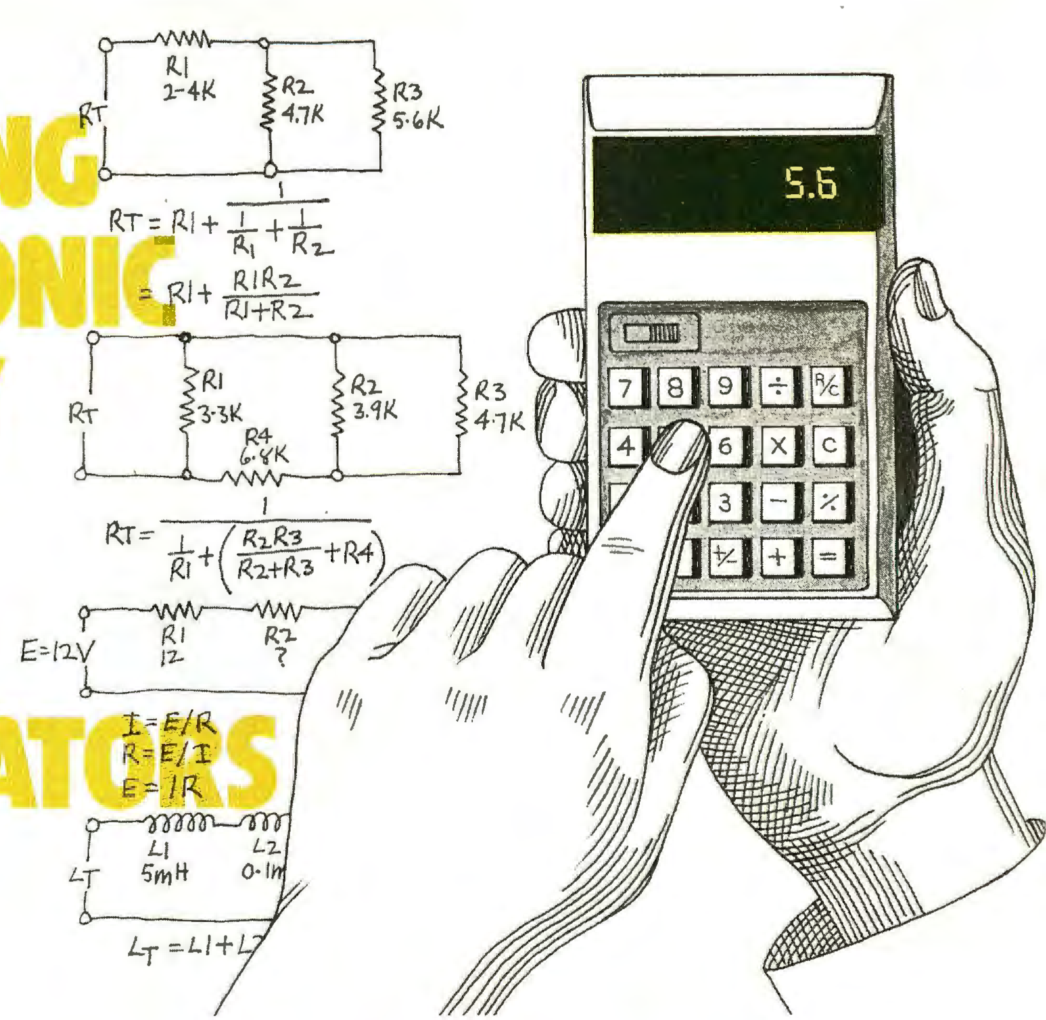
19. "DX-er Report," KDWN Las Vegas, NV. This 50-kW clear-channel station, which is *not* shortwave, spreads the DX hobby in the West and Southwest through a one-and-a-half-minute to two-minute spot. It is presented as a public service and compiled by members of the International Radio Club of America, the well-known medium-wave-only club. It naturally presents tips mostly on stations on the AM band and is intended as an introduction to the hobby for the many clear-channel listeners who have never heard of DX'ing. So it mixes general medium-wave news with interesting tips, particularly on easy foreign MW catches from western listening locations. Don't look for KDWN in the East or Great Lakes area. It has to put a deep null in its signal in the direction of the senior station on 720, WGN Chicago.

WEDNESDAYS

Time, GMT	Freq., MHz
0445-0447	(during Daylight Savings)
0545-0547	(in winter)
	0.72

20. Other DX Programs. The following stations carry DX programs, but they are either not regularly audible in North America or do not contain much of interest: Deutsche Welle, Radio Japan, Radio Kiev, FEBA Seychelles, ÖRF Austria, Radio Korea, Seoul, Sri Lanka B.C., Swazi Music Radio, and Radio Tashkent. ◈

LEARNING ELECTRONIC THEORY WITH HAND CALCULATORS



BY EDWARD M. NOLL

PART TWO: Reactance, Time Constants, and AC Calculations

IN THIS second installment on using the hand-held scientific calculator to learn electronics, we cover reactance, RC time-constants, and phasor calculations. As you will soon see, it is in the realm of ac mathematics that the scientific calculator is especially useful. Calculations involve finding squares and square roots of numbers. The numbers used in calculations are often very small, in the micro (10^{-6}) and pico (10^{-12}) ranges; while frequencies are in the megahertz (10^{6}) range. Right-triangle and phase calculations involve voltages, currents, and impedances in ac circuits.

Calculating Reactance. Simply defined, reactance (impedance) is the opposition an inductor (coil, transformer, etc.) or capacitor has to the flow of ac charges. It is expressed in ohms. Reactance is similar to the opposition to the flow of current presented by a resistor in a dc circuit but is considerably more complex in nature.

Inductive reactance can be calculated from the equation $X_L = 2\pi fL$, where f is the frequency in hertz and L is the inductive value in henrys. Using this equation, what is the reactance of a 20-H choke at 60 Hz? Your keyboard entries for solving this problem would be:

2 × π × 60 × 20 =
Display: 7539.82237

After rounding off, the answer would be approximately 7540 ohms.

Now, what is the inductive reactance of a 12-μH coil at 4 MHz? The solution is:

2 × π × 4 EE 6 × 12 EE +/−
6 = Display: 301.5928948

After rounding off, the answer would be 302 ohms.

To calculate capacitive reactance, you use the formula $X_C = 1/(2\pi fC)$. Again, f is frequency in hertz, while C is capacitance in farads. Now, what is the reactance of an 8-μF capacitor at 60 Hz?

2 × π × 60 × 8 EE +/− 6
= 1/x Display: 331.572798

The answer is roughly 332 ohms.

What is the reactance of a 100-pF capacitor at 4 MHz? The key sequence for solution of this problem is:

2 × π × 4 EE 6 × 100 EE
+/− 12 = 1/x
Display: 397.8873577

Rounded off, the answer is 398 ohms.

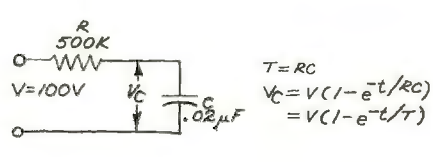


Fig. 1.

RC Time Constant. The time constant of a circuit is the product of resistance and capacitance and is expressed as T = RC, where T is in seconds, R is in ohms, and C is in farads. Therefore, if you wish to know the time constant for the component values shown in the Fig. 1, your keyboard entries would be:

5 EE 5 × .02 EE +/− 6 =
Display: 0.01 (second)

The answer can also be expressed as 10 ms (milliseconds).

The instantaneous voltage across a capacitor is an exponential related to the base e (2.718281828 obtained by operating the e^x key twice). The formula $V_C = V(1 - e^{-t/RC})$ is used for determining the voltage across a capacitor at any given time after power is initially applied to the circuit. Therefore to determine the voltage across the capacitor in Fig. 1 50 ms (0.05 second) after power is applied, the keyboard sequence would be:

100 × [1 − (+/− .05 ÷ 5
EE 5 ÷ .02 EE +/− 6) e^x]
= Display: 99.3262053

Note however that if you already know the time constant, you can simplify keyboard entry using the formula $V_C = V(1 - e^{t/T})$:

100 × [1 − (+/− .05 ÷ .01
) e^x] = Display: 99.3262053

In both cases, you obtain the same answer—about 99.3 volts.

If time constant T and time period t for the Fig. 1 circuit were both 0.01 second, −t/RC = −0.1/0.1 = −1. Using −1 as the exponent of e, we get:

100 − (100 × +/− 1 e^x) =
Display: 63.2120559

This calculation verifies the rule that states that, in one time constant, a capacitor charges to 63.2% of the maximum voltage in the circuit.

Now, what is the voltage across the resistor when −t/RC = −1? Since $V = V_C + V_R$, $V_R = V - V_C$:

100 − 63.2120559 =
Display: 36.7879441

Hence, the voltage across the resistor at the end of one time period is approximately 36.8 volts.

Ac Time Constant. Time constant is important when sine waves are

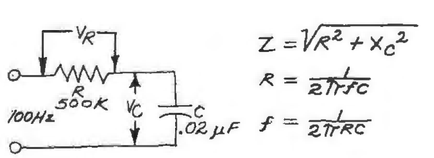


Fig. 2.

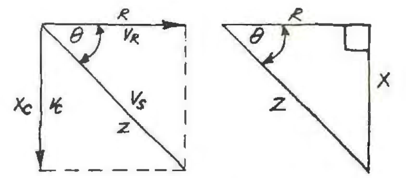


Fig. 3.

applied to resistor, capacitor, and inductor combinations. In the case of a sine wave, you cannot consider the voltage being applied as a constant as you do in dc circuits. Instead, the potential builds up gradually to peak amplitude. The reaction of the resistor-capacitor combination shown in Fig. 2 to the sine wave is a factor of frequency and the time constant of the network.

When the time constant is long compared to the period of the sine wave, the capacitor does not charge and discharge fully because the sine-wave variations are much faster than the time required to charge and discharge the capacitor by any appreciable amount. Consequently, the ac variations appear in their entirety across the resistor and not across the capacitor.

At low frequencies, where the sine-wave period is longer than the time constant, the capacitor does

same number system. Then continue to work the problem:

79.6 x^2 + 500 x^2 = $\sqrt{x}$
Display: 506.2965139

Hence, the circuit's impedance is roughly 506,300 ohms.

Now, at what frequency will $X_C = R$? The second equation in Fig. 2 allows us to derive the third equation, which is the one used for determining the frequency. Note that the denominator in the third equation contains the RC time-constant statement. Therefore:

2 × π × .01 = 1/x
Display: 15.9154943 (hertz)

If a 10-volt, 15.9-Hz signal is applied to the Fig. 2 circuit, how will the voltage divide? Inasmuch as reactance and resistance are basically the same, one might jump to the conclusion that 5 volts would appear across the resistor and 5 volts across the capacitor. This would be an incorrect assumption. Actually, 7.07 volts would appear across both elements. This does not

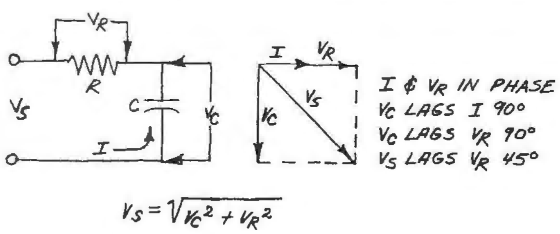


Fig. 4.

charge and discharge an appreciable amount. Therefore, there is likely to be a significant or even a great voltage variation across the capacitor, with a correspondingly lower variation across the resistor. To demonstrate this relationship, refer to Fig. 3. Note that capacitive reactance X_C lags resistance R by 90°. Therefore, the total impedance, Z, in the series RC circuit is a vector value somewhere between the resistive and reactive values. When you graph the values, a right triangle will result, with impedance Z becoming the hypotenuse.

To determine the impedance of the Fig. 2 circuit, use the first equation shown. Start by solving for X_C:

2 × π × 100 × .02 EE +/−
6 = 1/x Display: 79577.47151

Round off and convert the result to 79.6 k so that R and C are both in the

mean that the applied voltage is 14.14 volts because a vector relationship exists.

The angular relationship can be better understood by examining Fig. 4. The same current flows through both components. The voltage across the resistor is in-phase with the current, but the voltage across the capacitor lags the current by 90°. Therefore, the capacitor voltage lags the resistor voltage by 90°, which means that the resultant must fall between the two. To determine the value of applied voltage V_S, use the formula given in Fig. 4. So, assuming $V_C = V_R$ = 7.07 volts:

7.07 x^2 + 7.07 x^2 = $\sqrt{x}$
Display: 9.998489885

This proves that with a source potential of 10 volts, the voltages across the resistor and capacitor are both 7.07 volts when X_C = R.

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The same phase relationships exist between resistance, impedance, and reactance as shown in Fig. 5. Again, the right triangle is the basis of the phasor. With this in mind, calculate the reactance of the capacitor in Fig. 2 when f = 15.9 Hz:

2 × π × 15.9 × .02 EE +/− 6
= 1/x   Display: 500487.2423

Note that the answer, after rounding off, is very close to the 500,000-ohm value of the resistor. Assuming $R = X_C$ = 500 k, calculate Z:

500 x^2 + 500 x^2 = $\sqrt{x}$
Display: 707.1067811 (kilohms)

Ac Trigonometry. The modern hand-held scientific calculator permits the student of electronics to dispense with trigonometry tables when calculating angles. We find extensive use of sin, cos, and tan functions in ac vector calculations, as well as their arc functions ($\sin^{-1}$, $\cos^{-1}$, $\tan^{-1}$). The important relationships for the impedance vector are: $\sin\theta = X/Z$; $\cos\theta = R/Z$; and $\tan\theta = X/R$.

Knowing that reactance X_C is equal to resistance R, both being 500 kilohms, for the Fig. 2 circuit, $\tan\theta = X/R$ = 500 k/500 k = 1. From this, we can calculate the phase angle, $\theta = \tan^{-1} 1$:

1 $\tan^{-1}$ Display: 45 (degrees)

Once you know angle θ and resistance R, you can find the impedance from the formula $Z = R/\cos\theta$:

5 EE 5 ÷ 45 cos =
Display: 707106. 7813 (ohms)

This proves that the impedance of the circuit is approximately 707,000 ohms and not the simple arithmetical summation of X and R.

The angle at which X = R is 45°. For other frequencies and other reactance ratios, the same equations can be

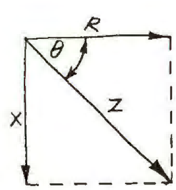


Fig. 5.

used. If any two quantities (X, R, Z) are known, angle θ can be calculated. The impedance can then be calculated. Likewise, when any two of the voltages are known, the third can be determined. A few examples will help to demonstrate these relationships in a series RC circuit.

First, in a series RC circuit that is to have an angle θ of 30°, X_C is 10,000 ohms. What resistor value is required? Using the formula $R = X_C/\tan\theta$, the calculator procedure would be:

10000 ÷ 30 tan =
Display: 17320.50811 (ohms)

The answer is approximately 17,320 ohms.

Next, calculate the impedance of a series RC circuit when X_C is 2000 ohms and R is 4000 ohms. Using the formula $\theta = \tan^{-1}(X/R)$, we get:

2000 ÷ 4000 = $\tan^{-1}$
Display: 26.5650511

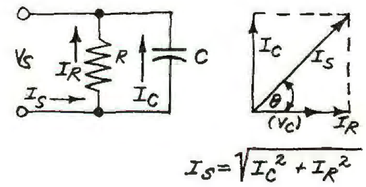


Fig. 6.

Then we find impedance using the formula $Z = R/\cos\theta$:

4000 ÷ 26.5650511 cos =
Display: 4472.135954 (ohms)

Now, prove that the above answer is correct by using the impedance formula:

2000 x^2 + 4000 x^2 = $\sqrt{x}$
Display: 4472.135954

As you can see, the answer checks out down to the last decimal place.

Finally, in a series RC circuit, R is 150 kilohms and f is 12,000 Hz. At what value of C will X_C be 500 kilohms? Start by solving for angle θ using the formula $\theta = \cos^{-1}(R/Z)$:

150 ÷ 500 = $\cos^{-1}$
Display: 72.5423969

The tangent equation can then be used to determine the required reactance to obtain a 72.54° angle:

150 × 72.5423969 tan =
Display: 476.969601

The final step is to determine the value of C that will produce a 476.97-kilohm reactance at 12,000 Hz. Use the formula $X_C = 1/(2\pi fC)$:

2 × π × 12 EE 3 × 476.96901
EE 3 = 1/x
Display: 2.780659563 −11

Hence, after rounding off the result, we know that the capacitor must have a value of 0.0278 μF when used with a 150-kilohm resistor to provide the required impedance at 12,000 Hz.

Parallel RC Circuits. In a parallel resistor-capacitor circuit, the applied voltage appears across both elements. (In any parallel circuit, the same voltage appears across each parallel leg.) The current, however, divides into separate components as a function of resistance and reactance. Likewise, the source current and the angle are related to the absolute and relative values of resistance and reactance.

In the resistive leg, the voltage and current are in-phase. Since source voltage V_S and capacitor voltage V_C are in parallel with resistor voltage V_R, they are in-phase with resistor current I_R as shown in Fig. 6. Capacitive current I_C must lead capacitor voltage V_C by 90° as shown. Therefore, in the parallel RC circuit, the source current must also lead resistor current.

The above relationship demonstrates that source current is not a simple summation of the resistor and capacitor currents. It is the vector sum:

$I_S = \sqrt{I_R^2 + I_C^2}$

Since the voltages across R and C are the same as the source, we can deal simply with impedances, so that

$(1/Z)^2 = (1/R)^2 + (1/X_C)^2$
or $Z = RX_C / \sqrt{R^2 + X_C^2}$

Impedance, therefore, is a product over sum relationship, much as is the case in which two resistors are connected in parallel. However, note that instead of a simple sum, a vector sum is required in the denominator.

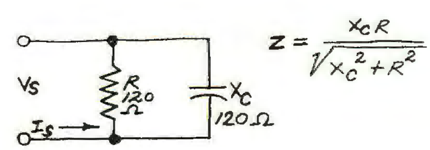


Fig. 7.

Calculate the impedance of the Fig. 7 circuit:

120 1/x x^2 + 120 1/x x^2 =
$\sqrt{x}$ 1/x   Display: 84.85281381
or 120 × 120 ÷ (120 x^2 + 120
x^2) $\sqrt{x}$ =   Display: 84.85281378

For all practical purposes, both answers are identical. Since R and X_C are equal, the calculations could have been simplified as follows:

120 1/x x^2 × 2 = $\sqrt{x}$ 1/x
or 120 x^2 ÷ (120 x^2 × 2)
$\sqrt{x}$ =

Answers in all cases will be within six-digit accuracy.

What is the source current if the source potential is 24 volts in Fig. 7? From Ohm's Law, we know that $I_S = V_S/Z$. Therefore

24 ÷ 84.8528138 =
Display: 2.828427123 −01

Translated, I_S is approximately equal to 283 mA.

A right triangle shows the vector relationship with angle θ between source current I_S and resistor current I_R, as in Fig. 6. The appropriate equations are: $\tan\theta = I_C/I_R = R/X_C$; $\cos\theta = I_R/I_S = Z/R$; and $\sin\theta = I_C/I_S = Z/X_C$. Now, using the tan θ formula, determine angle θ for the Fig. 7 circuit:

120 ÷ 120 = $\tan^{-1}$ Display: 45

Again, as in the series RC circuit, = 45° when $X_C = R$.

Calculate I_C and I_R for the Fig. 7 circuit. Use the sin θ and cos θ formulas — $I_C = I_S \sin\theta$:

.282842712 × 45 sin =

Display: 1.999999993 −01

and $I_R = I_S \cos\theta$:

.282842712 × 45 cos =

Display: 1.999999996 −01

Now find the vector sum of I_C and I_R:

.199999999 x^2 + .199999999 x^2

= $\sqrt{x}$ Display: .282842711

When X_C and R are not equal, the current in the circuit divides in accordance with the ohmic values of the reactance and resistance. With this in mind, calculate Z and I_S for the Fig. 8 circuit:

100 x^2 1/x + 10 x^2 1/x =

$\sqrt{x}$ 1/x Display: 9.950371903

or 100 × 10 ÷ (100 x^2 + 10 x^2) $\sqrt{x}$ =

Display: 9.950371903

Source current I_S can then be calculated:

100 ÷ 9.950371903 =

Display: 10.04987562

Phase angle θ becomes:

100 ÷ 10 = $\tan^{-1}$

Display: 84.2894069

From the answer obtained, it is obvious that this circuit is highly capacitive, since angle θ is much greater than 45°. Reactive current I_C is 10 times greater than resistive current I_R and source current I_S leads source voltage V_S by a substantial amount.

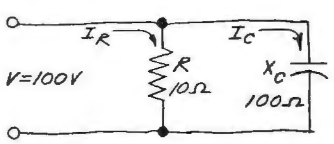


Fig. 8

Coming Up. This ends the second part of our series on using the hand-held scientific calculator for learning electronics. In the third and final part of the series, we will be covering frequency response and resonance, RC coupling, basic amplifier calculations, and RLC circuits. ◈

Product Test Reports

ABOUT THIS MONTH'S HI-FI REPORTS

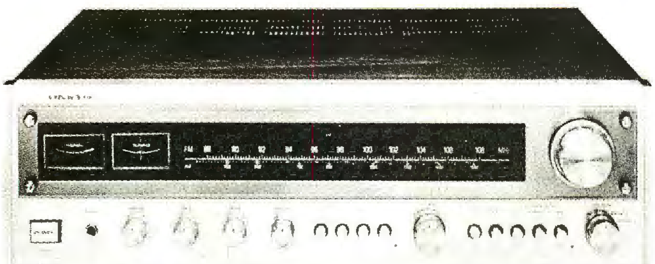
In addition to being an outstanding performer, Onkyo's Model TX-4500 AM/stereo FM receiver features a novel and highly efficient aid called "Quartz Lock Tuning." Combining some of the characteristics of afc and synthesized tuning, though it is neither, the system makes it literally impossible to tune in any FM station incorrectly.

From Denmark comes Bang & Olufsen's Beogram Model 1900 record player that provides foolproof operation. A single control combines speed selection, record indexing, arm lift, and vernier speed adjustment functions. Technologically, the record player is notable for its extremely low-mass tonearm (the arm and pickup are integrated), which enhances the ability to play warped discs.

—Julian D. Hirsch

ONKYO MODEL TX-4500 AM/STEREO FM RECEIVER

Phase-locked loop reduces FM tuning error to zero.



The Onkyo Model TX-4500 "Quartz Locked" stereo receiver features a novel and highly effective tuning aid that makes it virtually impossible to incorrectly tune in an FM station. Unlike conventional automatic frequency control (afc) that partially reduces tuning errors, the Quartz Lock is a phase-locked loop system that can reduce such errors to zero.

A 10.7-MHz crystal oscillator supplies the reference signal for the tuning system. The average i-f output from a received signal is compared to the reference signal, and any phase error produces a correcting voltage that "locks" the tuning to produce an i-f at exactly 10.7 MHz. The tuning knob is insulated from the panel and chassis. Touching it or even bringing a hand near it disables the PLL system to permit conventional tuning. When a signal is within locking range, the legend LOCKED appears in red above the dial scales. (If the broadcast is in stereo, a STEREO legend also comes on in red.)

Releasing the tuning knob allows the PLL circuit to take over after about 0.7 second, solidly locking the receiver to the signal. When this happens, the TUNED legend appears in green over the dial scales.

The receiver measures a fairly large 21¼" W × 17" D × 6½" H (54 × 43.2 × 16.5 cm) and weighs about 36.5 lb (16.6 kg). Price is $450.

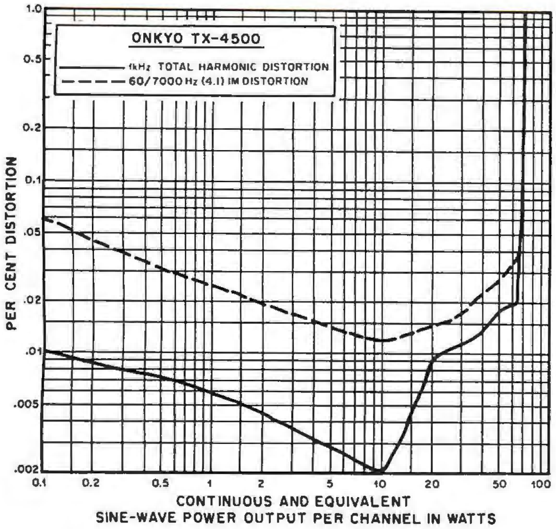
General Description. A pushbutton switch on the front panel of the receiver can be used to disable the Quartz Lock tuning system and interstation muting to permit tuning in very weak signals. Other pushbutton switches are assigned to the LOW and HIGH audio filters and LOUDNESS compensation. There are terminals on the rear of the receiver for connecting an external FM Dolby unit. The Dolby unit is inserted into the audio signal path by operating another pushbutton, simultaneously changing the FM deemphasis from 70 µs to the 25 µs required for proper Dolby operation.

The input SELECTOR has positions for AM, FM AUTO, PHONO 1, and PHONO 2. Its settings are keyed to corresponding illuminated legends above the dial scale. Unlike most receivers, this one has no AUX input dedicated to an external high-level program source. Instead, there are *three* tape recorder circuits, each of which is controlled by its own MONITOR pushbutton. One or two of these circuits can be used for AUX sources, leaving facilities for one or two tape decks. By pressing the appropriate buttons, it is possible to dub from recorder 1 to recorder 2 or 3 or from recorder 2 to recorder 3.

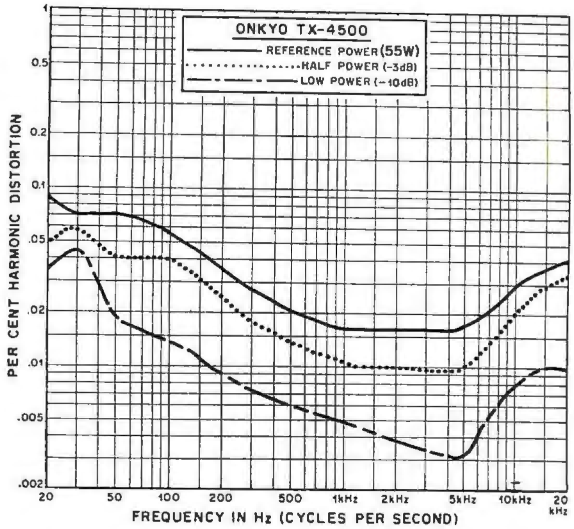
At the lower left of the control panel are a large POWER pushbutton and a headphone jack. All remaining controls are operated by turning knobs. They include a SPEAKERS selector that controls up to three pairs of speaker systems. Any pair or two combinations of two pairs of speaker systems can be activated. Alternatively, all speaker systems can be silenced for private headphone listening. The BASS and TREBLE tone controls each have 21 click-stop positions. The BALANCE control is center detented, and the VOLUME control has 41 click-stop positions.

Most of the upper half of the front panel is given over to the tuning dial scales and signal-strength and FM center-channel tuning meters. The dial area blacks out when power is turned off. It is clearly lit in white when power is on. The linear FM dial scale is unusually long, spanning 9" (about 23 cm), and has markings at 0.2-MHz intervals. To the right of the dial area is the large tuning knob that drives a very smooth flywheel mechanism.

On the rear apron of the receiver are separate preamplifier output and main amplifier input jacks that are normally joined together with removable jumper links. There is also a 4CH FM output ahead of the deemphasis circuits (for use with a future discrete demodulator) and a three-position slide switch that permits adjustment of the sensitivity of the Quartz Lock disabling circuit activated by the tuning knob. The antenna inputs permit



1 kHz total harmonic and 60/7000-Hz IM distortion (left). Harmonic distortion at 55 W, ½ power, and low power (right). Noise and sensitivity curves for FM section are given below.



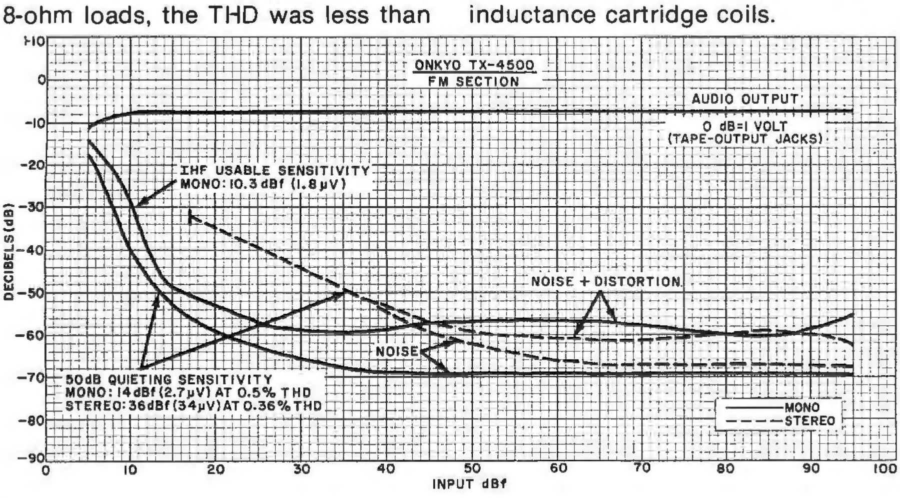
the use of either a 75- or a 300-ohm FM antenna and a separate wire-type AM antenna. There is also a hinged, but not pivoted, ferrite-rod AM antenna. The speaker terminals are insulated spring clips, and one of the three available accessory ac outlets is switched.

Laboratory Measurements. Following the standard FTC preconditioning period, the amplifiers delivered slightly greater than 70 watts/channel into 8 ohms at 1000 Hz before clipping occurred. Into 4 and 16 ohms, the measured power was 87.4 and 42.3 watts, respectively. At 1000 Hz, the THD was less than 0.01% between 0.1 and 30 watts and measured as low as 0.002% (the residual of our generator) at a 10-watt output. It increased gradually to about 0.11% at 70 watts, just before clipping. The IM distortion was between 0.01% and 0.02% at most power levels between 1 and 40 watts. It was only 0.43% at 70 watts. At very low power outputs, the IM rose slightly, to 0.4% at 2 mW.

At the rated 55 watts output into 8-ohm loads, the THD was less than 0.02% at middle audio frequencies. It rose to a mere 0.09% at 20 Hz and was 0.04% at 20,000 Hz, well within Onkyo's ratings. At lower power levels, the distortion was even less, typically between 0.002% and 0.01% at 5.5 watts output.

A phono input of 1.0 mV or a high-level input of 61 mV was required to drive the amplifier to a reference 10-watt output power level. Through either input, the unweighted noise level was 76 dB below 10 watts. Phono overload occurred at a high 225 mV.

The tone controls had a moderate, but adequate, range of about +7 to −10 dB, with a sliding bass turnover frequency and a treble response hinged at about 3000 Hz. The filters had 6-dB/octave slopes, with −3-dB response frequencies of 45 and 9000 Hz. The loudness compensation boosted both low and high frequencies. Phono equalization was accurate to within ±0.25 dB from 40 to 20,000 Hz and was virtually unaffected by cartridge inductance — less than 0.5 dB response change at any frequency when measured through high-inductance cartridge coils.



The performance of the FM tuner was equally impressive. The IHF usable sensitivity was as rated: 10.3 dBf (1.8 µV) in mono. The stereo sensitivity was set by the automatic switching threshold of 3 to 4 µV (about 16 dBf), which was also the muting threshold. For 50 dB of noise quieting in mono, a signal input of 14 dBf (2.7 µV) was required, yielding a THD of 0.56%. In stereo, the 50-dB quieting sensitivity was 36 dBf (34 µV), with 0.36% THD.

The ultimate S/N ratio at 65 dBf (1000 µV) input was 69 dB in mono and 67 dB in stereo, with respective distortions of 0.15% and 0.09%. (A lower distortion in stereo than in mono, although not usual, does occur occasionally.) We also measured the stereo distortion at the three frequencies called for in the IHF tuner standards. At 100 Hz, it was 0.44%, at 1000 Hz, 0.05%, and at 6000 Hz, 0.14% (all measured with L − R modulation at 100%).

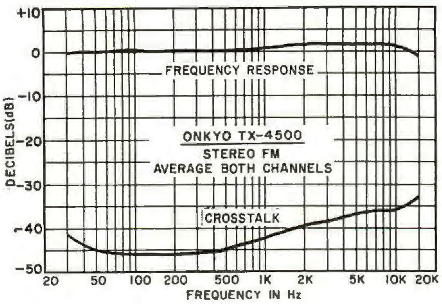
The FM tuner section had a frequency response flat within ±1 dB from 30 to 14,500 Hz, with most of the deviation occurring between 2000 and 10,000 Hz. The channel separation was equally good, measuring better than 45 dB from 50 to 500 Hz and still an excellent 33.5 dB at 15,000 Hz. The capture ratio was about 1.8 dB, AM rejection was 58 dB, and image rejection was 74 dB. Alternate-channel selectivity was asymmetrical, measuring 65 dB above the signal frequency and 82 dB below it, for an average of 73.5 dB. Adjacent-channel selectivity was 6.4 dB on the average.

It should be noted that the selectivity measurements, as with all other measurements, were made with the Quartz Lock system disabled. With it in use, the effective selectivity is greatly increased, since the phase

locking prevents a stronger signal from breaking through or from "capturing" the receiver. Using the Quartz Lock system, the effective rejection of either adjacent or alternate channel signals was in excess of 80 dB. The 19-kHz pilot carrier leakage was 66 dB below full modulation.

The only measurement we performed on the AM tuner section was frequency response, which was typical of most AM tuners we have tested. The AM response was 6 dB down at 65 and 3000 Hz.

User Comment. The test data clearly reveals that the Model TX-4500 is a very good receiver in every respect. Although a few high-priced FM tuners may surpass it in some selectivity and distortion characteristics, the differences are trivial. There can be no doubt that the sound quality in FM reception with this receiver will be determined only by the quality of the broadcast program. As for the audio amplifiers, harmonic and intermodulation distortion measurements are in a class with highly regarded audio amplifiers.



Frequency response and crosstalk averaged for both channels in stereo FM of Onyko TX-4500.

Although the Quartz Lock system might appear to be merely a super afc, it is actually much more than that. We verified that the tuning system invariably resulted in the lowest possible distortion and noise and the best stereo separation of which the receiver is capable. The automatic disabling system works so unobtrusively that one soon forgets it is there. Muting action is perfect, with total silence until the red LOCKED light comes on and the program is heard. Regardless of the reading of the tuning meter, which can be appreciably off center at the lock point, releasing the knob brings it to dead center as the green TUNED light comes on. The "pull-in" range of the Quartz Lock system appears to be about ±50 kHz. The dial is very accurately calibrated so that when the meter is centered, there is no doubt as to the channel to which the tuner is set.

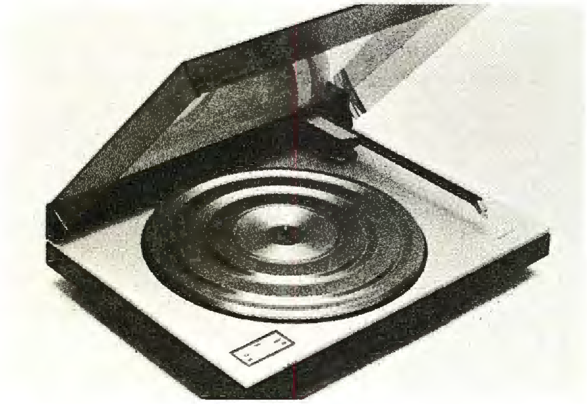
We noted that when playing records the sound had a definition and clarity that were unmistakable. To some extent, this might have been due to the maintenance of a true high-frequency response, instead of the couple of decibels of roll-off that often occurs above 10,000 Hz due to cartridge inductance interaction with the phono equalization. It has also been claimed that the exceptional dynamic range afforded by the receiver's high overload capability contributes to this result.

We did check the phono section with preequalized square waves, using a spectrum analyzer to detect any increase in the even harmonics in the output. We found no change in the spectral content of the square waves after they had passed through the phono preamplifier circuits.

CIRCLE NO. 80 ON FREE INFORMATION CARD

BANG & OLUFSEN BEOGRAM MODEL 1900 RECORD PLAYER

Integrated semiautomatic player handles beautifully.



The new Beogram Model 1900 record player, consists of a 33 1/3- and 45-rpm automatic single-play turntable and integrated tonearm/phono cartridge system. Beyond this, it has few similarities to its competitors. The conventionally pivoted tonearm has a rectangular, slim, magnesium alloy tube designed for high rigidity and low mass. The only phono cartridge it will accept is the B&O Model MMC4000, which is only a fraction of the size and weight of most conventional cartridges (to maintain a very low arm/cartridge mass characteristic).

There is only one operating control, a flat plate that measures about 2¼" × 1" (57.2 × 25.4 mm). It is mounted flush with the surface of the motorboard and provides all of the operational functions.

The record player comes mounted in a handsome rosewood veneered wood base. A tinted plastic dust cover that hinges open at any angle up to a full 90° is standard equipment. The system measures 17⅜" W × 13" D × 3⅜" H (44.1 × 33 × 8.6 cm) and weighs about 14 lb (6.4 kg). System price is $325.

General Description. The tonearm's counterweight is located over the pivots, with the arm tube fastened to its side. A plastic slider that moves along a calibrated scale on the arm is used for setting the tracking force over a range of 0 to 2.5 grams, the recommended force being 1 gram. The arm is balanced at the factory, but a screwdriver adjustment is available should it ever be necessary to reset it. The antiskating compensation system is built into the pivot design and is factory set to provide the proper compensation at the rated tracking force of the pickup.

The B&O cartridge does not have a user-replaceable stylus. If the stylus must be changed, the entire cartridge must be unplugged from the tonearm and returned to the company or one of its authorized service agencies. As with other B&O cartridges, the Model MMC4000 employs a moving-iron design with a "micro-cross" armature that varies the distribution of magnetic flux between its four pole pieces and is inherently symmetrical for all directions of stylus movement.

The 1.5-lb (0.68-kg) aluminum turntable platter is driven through a belt by an asynchronous induction motor, the speed of which can be adjusted over a nominal range of ±3% by an eddy-current brake. Speed selection is obtained by means of an idler wheel that moves to contact either of two different diameters of the motor shaft. A pulley on the idler shaft drives a larger central pulley, on which the platter rests, through a soft belt.

The platter has concentric rings to support the record and a ring of stroboscope markings in its label area. The turntable and tonearm support are rigidly linked by a subchassis, which is floated on compliant mounts from the motorboard to isolate the playing system from external vibration and shock and from motor vibration.

The single operating control is labeled 33 and STOP on the left side and 45 and PAUSE on the right. At the rear center of the control plate is the legend TURN, with + and − markings. The edge of a knurled wheel can be seen in the small gap between the control plate and brushed aluminum motorboard when the TURN section of the control plate is pressed.

To play an LP disc, 33 is pressed. The platter begins to rotate at 33 1/3 rpm, the tonearm swiftly indexes to the lead-in groove of a 12" (30.5-cm) disc, and after a couple of seconds lowers gently to the record surface. The audio outputs are muted whenever the pickup is not on the record. At the end of play, the arm lifts and returns to its rest position and the motor shuts off automatically. At any time during play, pressing the PAUSE side of the control lifts the pickup and in a few seconds shuts off the motor. Another touch of the 33 side of the control restarts the motor and lowers the pickup to resume play at the point from which it was lifted. Alternatively, if the tonearm is moved to another position, pressing the 33 portion of the control will cause the system to resume play at the selected point.

To play a single 45-rpm disc, a similar procedure is followed. (A large center hole adapter is provided.) The turntable is activated by pressing the 45 section of the control, where indexing is for 7" (17.8 cm).

Special disc combinations, such as 7" 33 1/3-rpm and 12" 45-rpm, cannot be played automatically, since the arm's indexing mechanism is internally coupled to the speed selected. Clearly, B&O did not intend for the system to be played manually, since the tonearm has no finger lift and is not easily cued when in its position.

When the TURN portion of the control plate is pressed and held down, the platter rotates but the tonearm does not leave its rest postion. This function can be used for cleaning a disc before playing or for adjusting the rotational speed of the platter with the knurled vernier control that becomes accessible when the plate is depressed.

The stroboscope markings on the platter are for 33 1/3 rpm only. The 45-rpm speed is adjusted automatically once the slower speed has been accurately set.

Laboratory Measurements. When we set the stylus force to 1 gram on the tonearm's scale, the measured force was exactly 1 gram. The cartridge did not lose contact with the heavily modulated low-frequency grooves of our Cook "60" test record, although it was on the verge of doing so.

The 1000-Hz, 30-cm/s tones of the Fairchild "101" test record were reproduced with symmetrical peak clipping, revealing that this very high velocity was beyond the linear operating range of the cartridge. The 300-Hz test tones of the German Hi-Fi Institute test record could be played up to the 70-micron level without serious mistracking, but some distortion was encountered in the right channel on the 50-micron band. This indicates that the antiskating compensation was insufficient for equally effective tracking of both channels.

When playing the Shure "Audio Obstacle Course—Era III" test record, the cartridge handled the highest levels of the musical bell and violin sections without audible mistracking. On the very difficult sibilant section, a trace of "sandpaper" quality could be heard on level 4 and definite mistracking on the maximum level 5. The maximum bass drum level also revealed a slight "crackle" that indicated incipient mistracking. These characteristics were not significantly improved by increasing the tracking force to 1.5 grams.

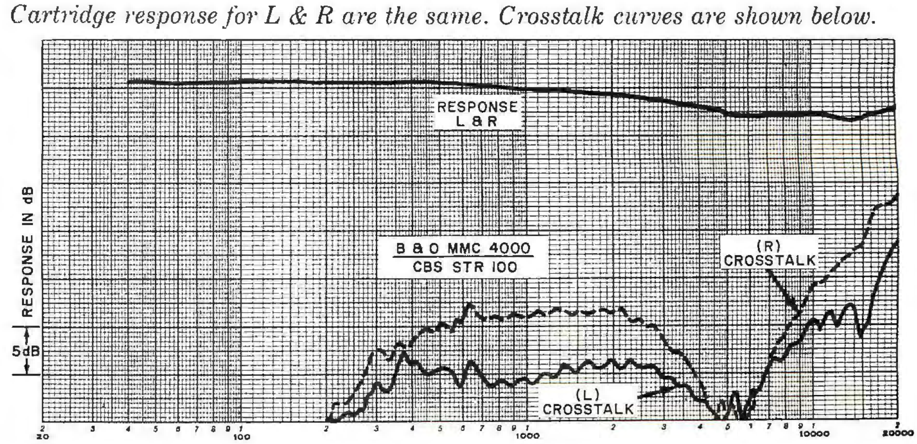
The frequency response of the cartridge, using the CBS STR100 record, was very smooth, with a gentle downward slope as the frequency increased from 500 to 15,000 Hz and a slight rise between 15,000 and 20,000 Hz. The overall frequency response was within ±2 dB over the full audio range. Channel separation was typically 20 to 25 dB and was down to about 10 dB at 20,000 Hz. The advantages of the very low mass of the tonearm were evident in the low-frequency resonance, which occurred at about 12 Hz, with a 5-dB amplitude.

IM distortion measurements with the Shure TTR-102 record revealed a low 1% to 2% distortion at velocities up to about 14 cm/s, a very high recorded level for most commercial recordings, and a smooth rise to 10% at 22.6 cm/s. The maximum level of this record (27.1 cm/s) could not be tracked by the cartridge. The distortion was somewhat less at a 1.5-gram tracking force, but not enough to justify its use. The high-frequency tracking distortion, playing the shaped 10,800-Hz tone bursts of the Shure TTR-103 record, was typical of most of the better cartridges we have checked. It increased smoothly from 0.8% to 2% as the velocity increased from 15 to 30 cm/s.

The output of the cartridge was 3.9 mV at a 3.54-cm/s velocity, with the channel levels matched within 0.5 dB. The vertical stylus tracking angle was 24°. The tracking error of the tonearm was less than 0.4°/in. for radii between 2½" and 6" (6.35 and 15.24 cm).

We were able to adjust turntable

Cartridge response for L & R are the same. Crosstalk curves are shown below.



speed over a range of from +3.8% to −3.2%. When we set the 33 1/3-rpm speed exactly, the 45-rpm speed was 0.8% high. Increasing the line voltage from 117 to 135 volts ac increased the speed by only 0.3%. Decreasing the line to 95 volts lowered the speed by 4.4%, most of the change occurring as the potential fell below 100 volts.

Wow and flutter measured 0.04% and 0.035% (unweighted rms), respectively. The unweighted rumble was 32-dB down (−36 dB with vertical components cancelled), and with RRLL weighting, it was 54-dB down. The isolation from vibration transmitted through the base was somewhat better than we have measured with most record players.

User Comment. The 1900's basic playing characteristics are those of a competent product. Judging from our lab tests, the cartridge itself couldn't be called "state-of-the-art" in its tracking ability. But this is not truly a limitation since we're only talking about very extreme velocities not found on commercial music recordings.

The downward sloping frequency response gives the cartridge a very neutral, uncolored sound, especially when it is compared to cartridges with peaked, or rising high ends (which gives a somewhat "sparkly" sound). Obviously, personal taste is an important factor in assessing these sonic differences. When played through speaker systems with a strong but smooth top-end response, the B&O cartridge leaves nothing to be desired with respect to clarity and musical quality.

The Model 1900 is undeniably one of the finest handling record players on the market. The operation of the control plate is so simple and effortless that playing discs becomes more automatic than on a record changer. Simply put a disc on the platter, touch the control plate, and lower the cover. Everything thereafter is automatic.

The absence of a finger lift or a lever to manually cue the pickup seems strange at first, but most manual cueing operations can be performed successfully with the arm in its raised position.

Of special import to us is the outstanding ability of the low-mass arm/pickup system to play the most severely warped records without a sign of distress. Our collection of warped discs is completely unplayable by any other pivoted tonearm we have used. (Only a low-mass radial arm, such as the one in the B&O Model 4002 record player, had been able to cope with them in the past.) Considering the prevalence of warpage in most discs, the importance of this feature cannot be overestimated.

In our view, the Model 1900 is an ideal choice for anyone who wants to listen to his records without aggravation and does not care to play the "battle of specifications" game. Additionally, it is an especially handsome unit, and its integrated construction eliminates the matching and assembly hassle usually faced.

REALISTIC MODEL TRC-57 NAVAHO CB TRANSCEIVER

AM/SSB base station features PLL and digital clock.

THE REALISTIC Model TRC-57 Navaho from Radio Shack is a 23-channel AM/SSB CB transceiver with a number of features to recommend it. Foremost among these features is a phase-locked frequency synthesizer that eliminates the need for channel crystals. Adding to the rig's sophistication is an electronic digital clock with LED display.

Private listening is conveniently available via a phone jack on the transceiver's front panel. Separate S/r-f and SWR meters make it possible to monitor SWR while observing relative output power. A noise blanker or a conventional noise limiter can be individually switched in and out. Additional facilities include r-f gain, a-f gain, variable squelch, and clarifier controls; LED's that indicate the mode of operation selected (AM/USB/LSB); PA service; external speaker jacks; detachable dynamic microphone; and front-facing speaker.

A built-in electronically regulated power supply permits the transceiver to be operated from conventional 117-volt 60 Hz ac power lines. Alternatively, a nominal 13.8-volt dc, positive- or negative-ground, power source can also be used, while providing full regulation. Hence mobile operation is possible with this essentially base-station transceiver. (Mobile mounting hardware is supplied.) The transceiver measures 13.75" W × 11.2" D × 5.8" H (35 × 28.5 × 14.7 cm). Price is $399.95.

Receiver Section. The receiver employs single conversion to a 7.8-MHz i-f, where selectivity and sideband selection are obtained with a crystal lattice filter. The front end consists of a diode-protected r-f stage and mixer. The i-f strip contains two stages. These are followed by the AM detector and anl, SSB product detector with bfo, amplified agc and squelch stages, audio amplifier, and an IC output stage that is also used as the AM transmitter modulator.

The noise blanker has two r-f stages, voltage-doubling pulse detector, and three-stage pulse amplifier with gating pulses applied to the collector circuit of the mixer. The r-f stages are tuned to 23 MHz, rather than to 27 MHz, to avoid triggering by CB signals.

A voltage-controlled oscillator (vco) furnishes the heterodyning signals for the receiver's mixer. It is set to the required frequency for each channel by means of the phase-locked loop (PLL) system. In the PLL system, a 10,000-Hz signal derived from the vco through a programmable dividing setup is compared at a phase discriminator with a 10,000-Hz standard signal derived from a crystal-controlled oscillator operating at 1 MHz. If the vco is not at the correct frequency, its derived comparison

signal will be other than 10,000 Hz (according to the dividing factor set up by the channel selector). An error voltage then appears at the discriminator to shift the vco until the exact 10,000-Hz signal is produced. The two 10,000-Hz signals are then locked in phase with each other, holding the vco at the proper frequency.

Our measurements on the receiver indicated a sensitivity of 0.5 μV on AM for 10 dB (S + N)/N at 30% modulation using a 1000-Hz signal. On SSB, sensitivity measured 0.15 μV at 500 Hz and 0.2 μV at 1000 Hz. Overall response was 300 to 2900 Hz on AM and 200 to 4400 Hz on SSB. Adjacent-channel rejection and desensitization were a minimum of 60 dB, while unwanted-sideband suppression was 50 dB at 1000 Hz.

Better-than-usual overload characteristics were exhibited by the receiver, which maintained good signal-handling capabilities with signals up to 10,000 μV in strength. Spurious unwanted-signal rejection was better than 60 dB, except at about 30.8 MHz, where it was 50 dB. I-f signal and image rejection were better than 80 dB.

The squelch was adjustable for thresholds between 0.5 and 1500 μV on AM and between 0.2 and 1500 μV on SSB. Excellent agc characteristics held the audio output to within 10 dB with an input signal change of 80 dB (at 1 to 10,000 μV), 6 dB of which change occurred at 1 to 10 μV. With very strong SSB signals, the release time was a bit fast, resulting in slight "pumping." However, this can be minimized by reducing the r-f gain. A 50-μV signal registered S9 on the meter.

Maximum sine-wave audio output power in both the receive and PA modes was 3 watts at 4% distortion into 8 ohms using a 1000-Hz test signal. We noted exceptionally good noise blanking. Using our impulse noise generator, the noise blanker attenuated noise peaks of 1000 μV or more (+60 dB above 1 μV) down to inaudibility in the presence of a 0.5-μV signal. The anl functions only on AM; its performance was highly effective.

Transmitter Section. The output of the receiver's bfo is combined with the vco signal by a balanced transmitter mixer to produce the on-channel carrier for AM transmissions. The SSB signal is generated by combining the bfo and microphone signals in an IC balanced modulator and filtering out the unwanted sideband with a crystal filter. The signal is then amplified and combined with the vco signal in the transmitter's mixer.

The r-f section of the transmitter consists of a predriver stage, driver and power amplifier stages, and a multi-Pi output network. The output amplifier works with the driver stage to function as a collector-modulated setup on AM and as a linear amplifier on SSB.

Speech compression, or amc, is obtained with a "bootstrap" setup around the microphone amplifier that, in effect, acts as an audio-frequency agc. On SSB, r-f output limiting (or automatic level control) is incorporated by using a rectified sample of the output to control the gain of the 7.8-MHz SSB amplifier.

The carrier output power on AM measured 3.8 watts. Using a 1000-Hz test tone and greater than 40 dB of amc compression, the modulation held to 90% and the sine-wave signal exhibited only 3% THD. Under dynamic (voice operation) conditions, due to a slightly slow amc attack time, the modulation tended to go to 100%, with a bit of overshoot on the negative peaks. Nevertheless, the adjacent-channel splatter held to at least 55 dB down.

On SSB, using a two-tone test signal, the output power measured slightly greater than 12 watts pep. Third-order distortion products were an excellent 24 dB below the test tones (30 dB below pep), which is about the best performance we have ever obtained from a solid-state transmitter. However, with our voice test and using 40 dB of compression, the pep output initially tended to go to about 15 watts pep, with some flat-topping and deterioration of third-order distortion to 24 dB below pep. This was due to a slow alc attack time. Splatter was still way down, carrier suppression was 45 dB, and unwanted-sideband suppression was 50 dB at 1000 Hz.

The overall response on AM was 200 to 3500 Hz at the 6-dB points and was 300 to 3200 Hz on SSB. As might be expected from the PLL synthesizer system, the transmitter's frequency tolerance was the same on all channels, measuring nominally about minus 200 hertz.

User Comment. The transceiver is well styled and is easy to operate. Con-

trol knobs are large and easy to grip. The meters are large in size and illuminated for easy readability.

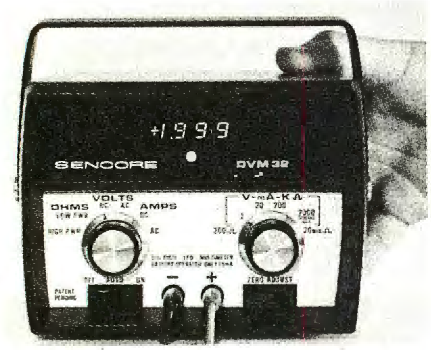
The digital clock can be set up to display time in either 12- or 24-hour format. The clock does not function when the transceiver is powered from a dc source. The setting time may be quickly or slowly advanced or held to allow the actual time to catch up with the display.

From the results of our tests and description of the various operating facilities, it should be evident that this transceiver is capable of superb performance. If you are looking for a full-feature AM/SSB transceiver that can do double duty as a base station and a mobile rig, this one is certainly worth serious consideration.

CIRCLE NO. 82 ON FREE INFORMATION CARD

SENCORE MODEL DVM32 PORTABLE DMM

Rugged, autopolarity, 3½-digit multimeter with large LED readout.



A FEW YEARS AGO, the typical digital multimeter was a relatively expensive, bulky piece of test gear. It required a lot of power, which tied it to the ac line and made it into a bench instrument. By contrast, the modern DMM has all the versatility, portability, compact design, and light weight of the traditional VOM. Prices have also come down considerably since the first DMM's were introduced.

Typical of the latest DMM's is the Sencore Model DVM32, which is priced at only $198. This battery-powered portable instrument measures only 7″ W × 5″ H × 4″ D (17.8 × 12.7 × 10.2 cm) and weighs 2¼ lb (1 kg). The instrument is housed in an impact-resistant Cycolac® case, the front edge of which forms an overlap surround to protect the controls and display from damage. The DMM's carrying handle doubles as a tilt stand.

The Model DVM32 is an autopolarity instrument. It is designed to measure both ac and dc voltage and current and high- and low-power ohms. The function and range are selected by separate rotary switches.

Technical Details. The numeric display consists of 3½ digits of 0.3″ (7.62-mm) seven-segment red LED numerals, plus a LED +/− indicator. Plus is displayed, not implied. Current drain from the four C cells, which can be ordinary carbon zinc or rechargeable types, is only 15 mA to ensure long battery life. (An optional No. 39G90 ac power adaptor is available for $9.95 to permit the DMM to be line powered for bench use.)

There are four dc voltage ranges that provide a maximum indication of ±1999 volts. Accuracy is 0.5% of full scale. Input resistance in the dc voltage function is 15 megohms. All ranges are protected to 2000 volts dc plus peak. Ac rejection is specified at 40 dB between 50 and 60 Hz.

Ac potentials up to 1000 volts rms can be measured in four ranges with an accuracy of 1.5% at 60 Hz and 3% for the three digits. The frequency range on the ac voltage function is from 40 to 3000 Hz ±1 dB. Input impedance is 1.8 megohms shunted by 18 pF. The input is protected to 1000 volts rms plus dc on all of the voltage ranges.

There are two resistance-measuring functions, one for low-power ohms with 80 mV at the test probes and the other for high-power (conventional) ohms with 800 mV at the probe. The low-power mode has five ranges that go up to 1.999 megohms and provide a measuring accuracy of 1% of full scale. The high-power ohms mode also has five ranges, this time to 19.99 megohms, with an accuracy of 1% on all ranges except the highest, where the accuracy is stated as being 5%. In both resistance-measuring modes, the circuit is protected for inputs of up to 1000 volts dc plus peak on all ranges.

Both ac and dc current measurements can be performed on four ranges, with a maximum measuring capability of 1999 mA (1.9 amperes). Accuracy on both ac and dc is stated at 1%. The input is protected by a diode and a fuse.

The instrument has an interesting AUTO mode. With the front panel switch set to this mode, the power-consuming display comes on only when an actual measurement is being made (thus the reason for the long battery life). On standby, the internal circuits are operating, but the display is extinguished. Of course, if desired, the AUTO feature can be switched out, in which case, the display remains constantly on.

A 200,000-ohm isolation probe comes with the DMM. If potentials up to 50 kV must be measured, an optional No. 39691 high-voltage probe is also available.

User Comment. We performed our usual battery of accuracy tests on the DMM, using high-precision voltage sources and resistors. In all cases, the multimeter easily met or bettered its published specifications. Our use test of the DMM included a week at a busy workbench and an extended stint in the field. Our conclusion is that this instrument is as easy and automatic to use in either environment as any DMM we have tested in the recent past.

The large, bright display is easy to read under just about every ambient lighting condition and over a wide range of viewing angles. The controls operated with positive action and were large enough for a comfortable grasp. On several occasions when the DMM was used on battery power over a period of several hours, we came to really appreciate the battery-saving AUTO mode. We also found that replacing depleted batteries was a simple procedure. Simply remove one screw and the upper rear plate of the housing to remove the old and then replace with fresh cells.

We would not hestitate to recommend the Sencore Model DVM32 to anyone — service technician or hobbyist/experimenter — as an all-in-one test and measurements instrument for bench and field use. It is a practical size for lugging along on field jobs. It is ruggedly built to bear up under rough handling.

CIRCLE NO. 83 ON FREE INFORMATION CARD

Solid State

By Lou Garner

SIMPLE STOPWATCH SPLITS SECONDS!

ALTHOUGH electronics may be one of your major hobbies, if you're a typical reader, chances are you're interested in a number of other things as well . . . track, perhaps, or wrestling, boxing, swimming, skiing, sailing, horse racing, skating, skeet, target shooting, rally driving, archery, chess, photography or chemistry. In many of these activities, it may be desirable to time an event or series of events with reasonable accuracy and, for this, a stopwatch is a virtual necessity. Fortunately, there's a wide choice of commercial instruments available for nearly all timing applications, from chemical reactions to photographic exposures, from sports matches to the single lap of a race, and from a chess move to the driving (or sailing) coverage of a measured distance. You can choose a conventional mechanical hand-wound type or a sophisticated digital electronic unit at prices ranging from less than fifty to more than two hundred dollars, depending on the accuracy and operational features needed for your application. On the other hand, if you prefer to "roll your own," you can assemble a versatile multi-function digital stopwatch at modest cost and with minimum effort by using an IC introduced late last year by *Intersil, Inc.* (10900 N. Tantau Ave., Cupertino, CA 95014). The resulting instrument features a timing range of up to 59 minutes 59.99 seconds in one-hundredth of a second increments, a low-battery indicator, crystal control, and two operating modes, yet requires, in addition to the IC, only a six-digit LED display, four spst switches, a quartz crystal, a small trimmer capacitor, and three penlight cells, plus a case and customary hardware.

Designated type ICM 7205, Intersil's stopwatch IC is a single chip CMOS device designed to interface directly with a six-digit/seven-segment common-cathode LED readout, and is capable of furnishing a multiplexed drive current of up to 13-mA per segment with a nominal 3.8-volt dc source. It is suitable, however, for use on 2-to 5-volt dc supplies and is fully protected internally against damage from static charges, thus eliminating the need for special handling and wiring precautions. The unit has a maximum power dissipation rating of 0.75 watts and a specified operating temperature range of from −20°C to +70°C. The device contains an integral oscillator, high- and low-frequency dividers, a multiplex generator, control logic, counters, a decoder, digit and segment drivers, and a low-battery sensor/indicator driver. In operation, the circuit divides the 3.2768-MHz signal generated by the crystal controlled oscillator by 2^{15} to obtain 100 Hz, which is then fed to the fractional seconds, seconds and minute counters. An intermediate frequency is used to develop a one-sixth duty cycle 1.07-MHz signal for multiplexing the display drivers. The blanking logic provides leading zero blanking for seconds and minutes independently of the clock.

Described in Intersil's 6-page technical bulletin for the ICM 7205, the stopwatch schematic shown in Fig. 1 is

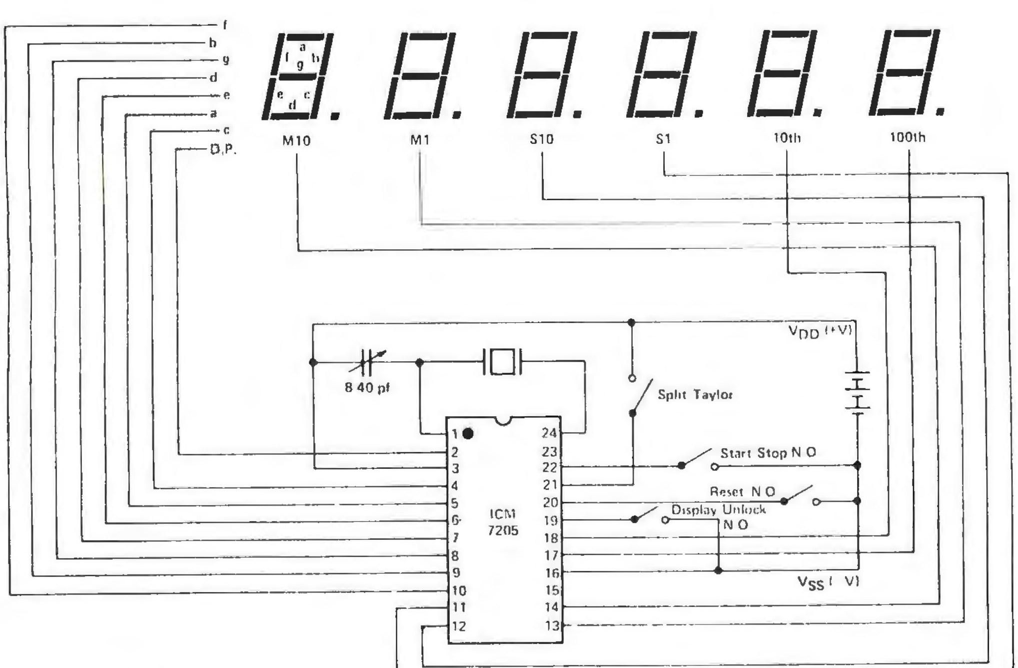


Fig. 1. Circuit for stopwatch using the 7205 chip.

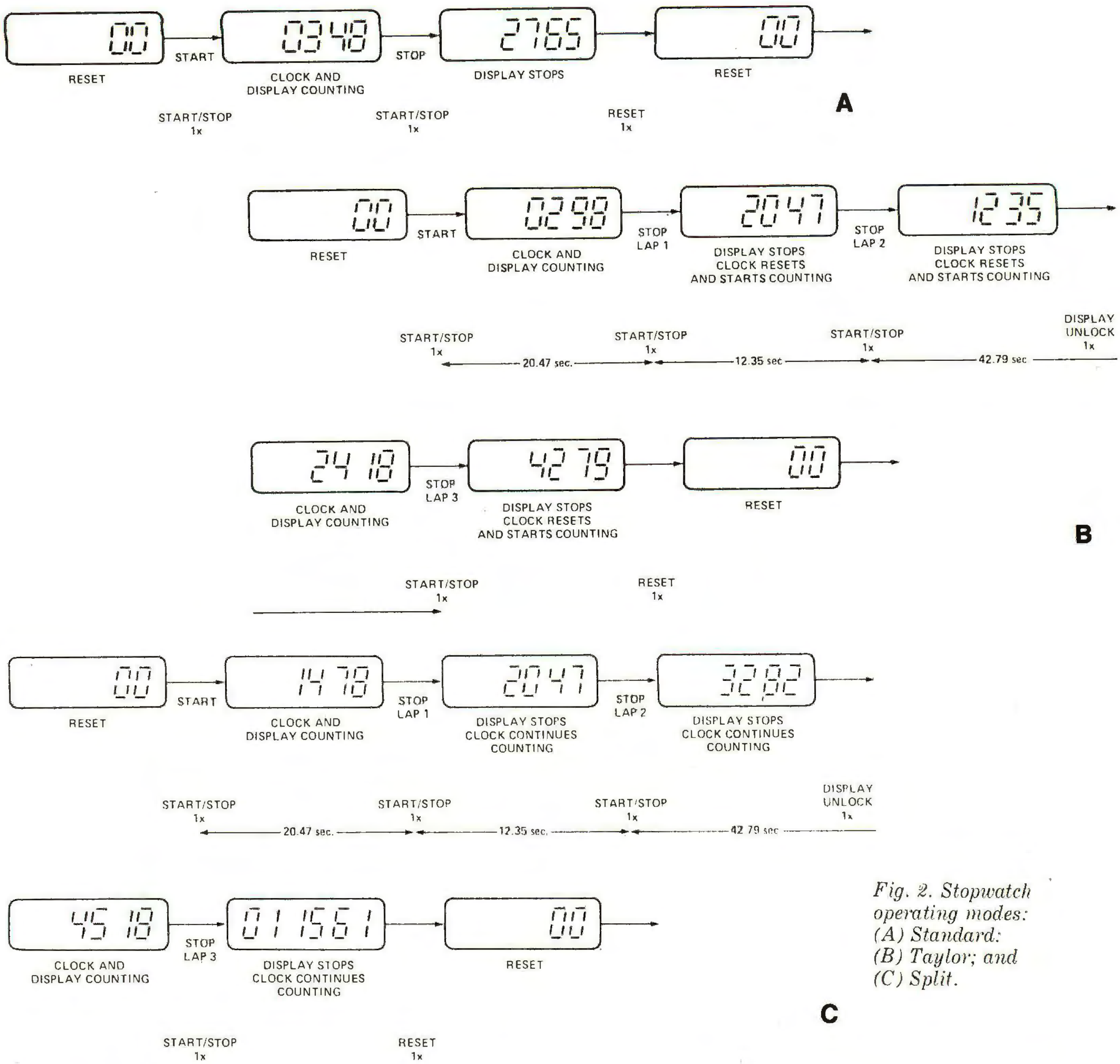


Fig. 2. Stopwatch operating modes: (A) Standard; (B) Taylor; and (C) Split.

complete except for an optional "on-off" power switch. If used, this may be a spst unit connected in series with either power supply lead. The power source consists of three series-connected AA cells or equivalent rechargeable NiCd units. Since standard components are specified, most of these should be readily available through local dealers. However, depending on the individual's location, it may be necessary to order the IC and crystal through one of the larger mail-order distributors. The manufacturer specifies that the quartz crystal used to control the oscillator's frequency should be a 3.2768-MHz unit with an R_S of 50 ohms and a load capacitance of 15 pF. If a different crystal is used, it may be necessary to change the trimmer capacitor's value (shown as 8 to 40 pF) to achieve optimum performance.

With neither parts layout nor lead dress critical, the individual builder may use either PC or perf board construction techniques when duplicating the circuit, as preferred. Good wiring practice should be followed, of course. For best performance, the spst START/STOP switch should be a high-quality, normally open pushbutton type with low "bounce" (less than 15 ms) characteristics. After assembly and checkout, the oscillator trimmer should be adjusted for precise operation, checking the unit against an accurate standard, if available.

In practice, switching the stopwatch "on" will reset the circuits and display "*00*" in the fractional seconds position, with all other digits blanked. This display always indicates that the stopwatch is ready for operation. The instrument may be used in either of two modes in addition to that of a standard stopwatch. All three operational modes are illustrated graphically in Fig. 2. For timing a single event, the START/STOP and RESET switches are used. As shown in Fig. 2(A), depressing the START/STOP switch starts the clock and display counting. At the end of the timed event, depressing the START/STOP switch stops the display, permitting a readout of the time interval. Initially, only fractions of seconds are displayed, with seconds shown after one second and, finally, minutes after the first minute, providing a full display. Since the maximum range is 59 minutes 59.99 seconds, the user must remember the number of hours if the timed event exceeds an hour. Lead-

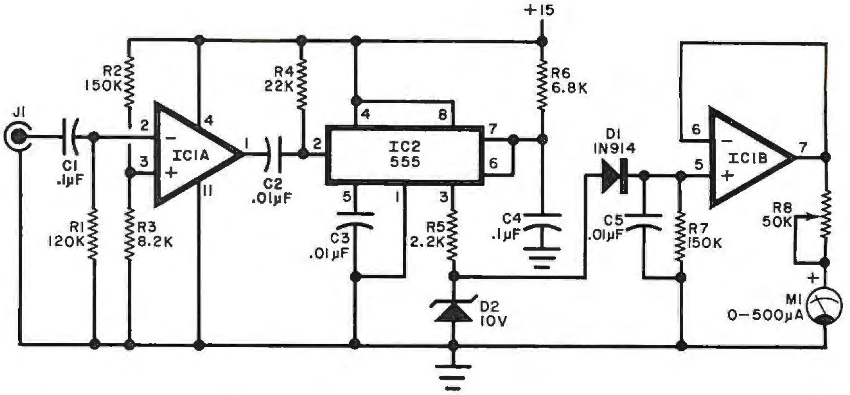


Fig. 3. Ted Reiter's frequency-to-voltage converter circuit.

ing zeros are not blanked after the first hour. Once the event is timed, the instrument can be reset for another measurement by operating the RESET switch. The TAYLOR (or sequential) mode is used when timing a series of rapidly occurring events where the individual time for each event is of immediate interest, rather than the total time. Here, the SPLIT/TAYLOR switch (Fig. 1) is left open and the instrument is controlled using the START/STOP, DISPLAY UNLOCK, and RESET switches. As depicted in Fig. 2(B), depressing the START/STOP switch initially starts both the clock and display counting. At the end of the first event, depressing the START/STOP switch stops the display and resets the clock, which starts counting again. The display remains stationary after the first interval, showing the last previous time, until the START/STOP switch is actuated, which causes the display to show the next interval. Operating the DISPLAY UNLOCK switch will permit the display to show the running clock at any time. Upon completion of the timing tests, the stopwatch is reset by actuating the RESET switch. Finally, for those events where the user is interested in the cumulative time intervals for a series of events, the stopwatch can be operated in the SPLIT mode. Here, the SPLIT/TAYLOR switch is closed. Afterwards, depressing the START/STOP switch starts the clock and display counting, as shown in Fig. 2(C). At the end of the first event, the START/STOP switch stops the display but permits the clock to keep counting. Thereafter, the cumulative time can be read after each succeeding event by operating the START/STOP switch. Whenever desired, the DISPLAY UNLOCK switch may be used to let the display "catch up" with the running clock. At the end of the series of events, the RESET switch reestablishes initial starting conditions but, of course, this control can be used at any time.

The optional on-chip low battery indicator (LBI) is intended for use with a separate LED or with the decimal points of the digital readout. Its output (pin 2) is a p-channel transistor of approximately half the size of one of the segment drivers. The circuit is designed to maintain a voltage difference between the LBI trigger level and the minimum operating voltage. Thus, the lower the LBI trigger voltage, the lower the minimum operating voltage. In practice, this means that the stopwatch will provide at least 15 minutes of accurate timekeeping after the LBI turns on, assuming that the power pack consists of three size AA cells.

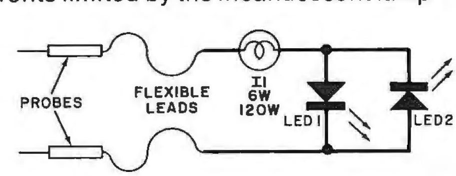
Readers' Circuits. A previous contributor to these pages, Ted Reiter (1442 Brook Drive, Titusville, FL 32780), suggests the circuit illustrated in Fig. 3 as an alternative frequency-to-voltage converter for experimenters who may not have access to Raytheon's new 4151, described in the April column. Ted developed his circuit for use in conjunction with a project involving the measurement of solar intensity levels translated into varying audio tones. Requiring a 3-volt rms input signal, the circuit drives a standard 500-µA meter and is designed for optimum performance between 100 and 500 Hz.

In operation, the input signal is applied through coupling capacitor *C1* to op amp *IC1A,* biased by voltage-divider *R2-R3* for operation as a modified Schmitt trigger. The amplified output signal is applied through a differentiation network, *C2-R4,* to a one-shot, *IC2,* which delivers fixed width output pulses to a peak limiting circuit, *R5-D2.* The pulses are then coupled through detector diode *D1* to a pulse integrator, *C5-R7.* Since the pulses applied to the integrator are of constant width and amplitude, the instantaneous voltage developed across *C5* will be directly proportional to the pulse repetition rate and hence to the frequency of the original signal. This voltage is amplified by a second op amp, *IC1B,* and used to drive the output meter, *M1.* Potentiometer *R5* is used to set the meter's full scale reading at the highest frequency measured (500 Hz).

Ted has specified standard, readily available components in his design. Op amps *IC1A* and *IC1B* are two sections of a type 324 quad op amp (the other two sections are available for other circuit applications), while *IC2* is a familiar 555 timer. Zener diode *D2* is a 10-volt, 400 mW type. All resistors, except for calibration potentiometer *R8,* are ¼- or ½-watt types, and the capacitors are small ceramic, plastic film or paper units. Operating power, nominally 15 volts, is actually furnished by a pair of series-connected 9-volt transistor batteries. Neither component layout nor wiring dress should be overly critical and the builder, therefore, may follow his own inclinations regarding construction methods when duplicating the circuit.

Peter Lefferts (1640 Decker Ave., San Martin, CA 95046), one of our more prolific west coast contributors, has submitted another interesting design . . . a wide range voltage probe. Pete's circuit, given in Fig. 4, requires but three basic components: a 6-watt, 120-volt incandescent lamp, *I1,* and a pair of type NSL 5023 or NSL 5024 light emitting diodes, *LED1* and *LED2.* Despite its simplicity, the probe can indicate the presence of *any voltage from 1.5 to 150 volts ac or dc,* with either the lamp (*I1*) or one (or both) of the LEDs illuminated. The circuit depends, for its operation, on the unique characteristics of the incandescent lamp's filament. At lower voltages, only the LEDs are activated, with their currents limited by the incandescent lamp

Fig. 4. Peter Lefferts's wide-range voltage probe.



serving here as a simple series resistor. At higher voltages, the rapidly increasing resistance of the lamp's filament limits the LEDs' currents to about 50 mA at full line voltage, or about 25 mA average for an ac input. If desired, one of the probes can be "polarized" for dc checks, with the corresponding LED illuminated at correct polarity. For example, if the upper probe (Fig. 4) is considered *positive*, *LED1* is illuminated when correct polarity is applied, with *LED2* indicating reversed polarity. The circuit can be assembled in a small metal chassis box with test jacks, in a plastic case with flexible test leads, or self-contained within a cylindrical tube, at the builder's option.

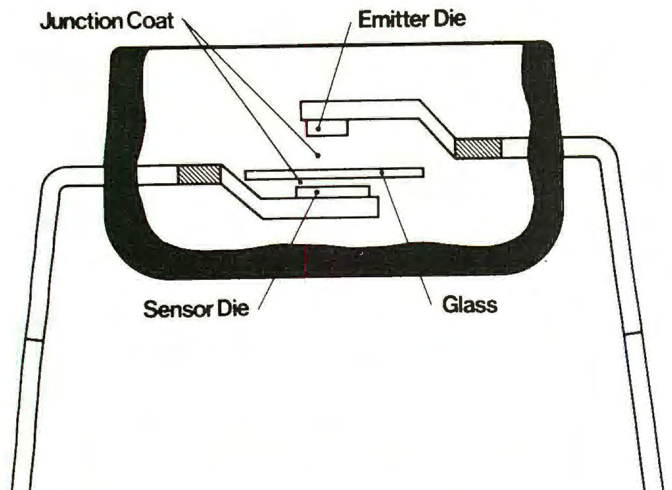


Fig. 5. Cross-section sketch of Fairchild's new optocoupler design.

Data Up-Date. The *National Semiconductor Corporation* (2900 Semiconductor Drive, Santa Clara, CA 95051) has released a number of new handbooks which should be of major interest to serious hobbyists and experimenters. The handbooks, listed below, may be purchased through the firm's franchised distributors or ordered directly from the manufacturer's Marketing Services Department (California residents should add 6% sales tax to the indicated prices):

The *PACE Technical Description* is a 96-page handbook describing the firm's "PACE" single-chip, 16-bit microprocessor. The volume describes both the full-feature CPU and the entire complement of hardware and software items that comprise the "PACE" (Processing And Control Element) system, showing in detail the family of support chips, application cards, software support (including program examples), and microprocessor development systems. Applications as well as operations are described, along with product and instruction summaries. The PACE manual is priced at $3.00/copy.

Interface Integrated Circuits is the title of a 464-page data handbook which gives specifications on the firm's complete line of interface products, including peripheral/power drivers, level translator/buffers, line drivers and receivers, memory and clock drivers, sense amplifiers, display drivers, and optocouplers. The text is supported by graphs, charts and diagrams. Also included is a 72-page section of application notes covering such topics as transmission lines, data transmission in high-noise environments, and driving gas discharge and LED displays, together with product selection guides listing specifications for LED drivers, peripheral drivers and transmission drivers, and two cross reference guides comparing product type numbers of other manufacturers. The Interface handbook carries a price tag of $4.00/copy.

The *TTL Data Handbook* describes National's complete line of bipolar logic devices, giving full specifications and electrical performance characteristics on standard 54/74 TTL, low-power 54L/74L, high-speed 54H/74H, ultrahigh-speed Schottky 54S/74S, low power Schottky 71LS/81LS, Series 9000 TTL, Series 10,000 ECL, and Series 930 DTL. It covers gates, buffers, drivers, flip-flops, latches, registers, counters, selector/multiplexers, multipliers, comparators, decoders, parity generators, and related devices. A Tri-State selection guide, an industry cross reference guide and a functional index also are included, as well as package outlines. The *TTL Data Handbook* may be obtained for $4.00/copy.

The *Memory Data Book* is a 544-page volume covering the manufacturer's memory and memory-related products, including bipolar, MOS, CMOS RAMs, field and mask programmable ROMs (bipolar and MOS), MOS shift registers and PLAs. In addition, the book describes interface/support circuits for memory operation and includes pertinent application notes, cross reference guides and a production status guide on National memories as well as complete specifications, characteristics, diagrams and special features of the products. The price is $3.00/copy.

Finally, the *SC/MP Technical Description* is a 65-page handbook which describes the firm's single-chip 8-bit "SC/MP" (Simple-to-use, Cost-effective, MicroProcessor), a CPU requiring only one memory chip to form a complete, fully-programmable system. Starting with a general introduction to "SC/MP" for non-technical users and following up with complete details for preparation of a preliminary design of "SC/MP"-based applications, the book includes 6 tables and 35 illustrations. The software described includes cross assemblers, loader/debug utilities, and input/output routines. Also outlined is a description of three application modules. The volume is $3.00/copy.

Device/Product News. Both *Fairchild*'s Linear Integrated Circuits Division (464 Ellis St., Mountain View, CA 94042) and Optoelectronics Division (4001 Miranda Ave., Palo Alto, CA 94304) have introduced new devices of potential interest to experimenters and hobbyists, including a line driver and receiver, a series of Darlington arrays, a family of high-voltage opto-couplers, and what is claimed to be the largest single digit LED display available in the industry. The 9636 and 9637 are monolithic circuits intended for applications in data communication and data terminal equipment. Of these, the 9636 is a dual single-ended line driver that provides TTL and CMOS compatible inputs and features an output slew rate that can be controlled with a single external resistor as well as short-circuit protection for all outputs. The 9637 is a Schottky dual differential line receiver providing a TTL compatible output and offering an input threshold accuracy of ±200 mV over a ±7-volt common-mode range. Both the 9636 and 9637 are supplied in 8-pin miniDIPs, making it possible to insert two devices in a single 16-pin DIP socket for use as a quad-input assembly. The new series of Darlington arrays comprises six high-voltage, high-current units intended for interfacing TTL and MOS logic circuits with such devices as solenoids, relays, lamps, small motors and LED displays. The basic devices, types 9665, 9666 and 9667, are rated at 50 volts, with 80-volt units available and identified

by an "A" suffix (i.e., 9665A, etc.). All six devices feature seven high-gain Darlington transistor pairs per package, each capable of furnishing output currents of up to 350 mA, with suppression diodes provided for use with inductive loads. Outputs may be paralleled to increase load capabilities. The 9665 is a general purpose array which can be used with DTL, TTL, PMOS or CMOS logic and features input current limiting set by means of external resistors. The 9666 eliminates the need for external resistors and is specifically designed for direct interfacing with PMOS logic to solenoids and relays; it operates at supply voltages from 14 to 25 volts. The 9667 has a series base resistor connected to each Darlington pair for direct operation with TTL or CMOS logic powered by 5-volt sources. The Darlington arrays are available in either plastic or ceramic DIPs. *Fairchild*'s new family of phototransistor couplers offers a minimum isolation voltage of 5,000 volts for all device types. This high rating, more than twice that of standard couplers, is achieved by using glass as an internal insulating spacer between the light source and phototransistor, as shown in Fig. 5. Finally, the firm's Optoelectronic Division is offering a group of 0.8-inch high LED display digits readable at distances of up to 30 feet. The new displays are available in common cathode or common anode versions with either a left or right-hand decimal point. Common-cathode types are the FND800, right-hand decimal, and the FND850, left-hand decimal. Common-anode types are the FND807, right-hand decimal, and the FND847, left-hand decimal. With an average intensity per segment of 0.15 millicandela, the displays require a 1.7-volt source and an average drive current of 5-mA per segment.

If your plans include projects involving telephone dial tone control, you'll want to investigate a new pair of ICs announced recently by the *MOSTEK Corporation* (1215 W. Crosby Road, Carrollton, TX 75006). The new devices, designated types MK 5085 and MK 5086, combine CMOS logic, D to A converters, an operational amplifier, and bipolar transistors on a single chip, and are designed to use an inexpensive 3.58-MHz crystal reference to produce eight distinct audio sinusoidal frequencies, which are mixed together on chip to provide high accuracy tones suitable for dual tone dialing. Both circuits are identical except for keyboard configuration. The MK5085 utilizes a self-scanning technique to interface directly to a class-A or 2-of-8 keyboard, while the MK5086 interfaces to either a 2-of-8 keyboard or other electronic systems. Common key functions such as switching out the transmitter and switching in muting resistance are accomplished electronically. The MK 5085 was designed using CMOS primarily for integration into telephone systems where it is possible to derive the necessary power directly from telephone lines; non-telephone hobbyist applications may use a fixed dc supply such as four AA cells or a single 9-volt battery. In operation, distinct audio frequencies are obtained when keyboard entries select the proper digital dividers to divide the 3.58-MHz crystal signal. These signals are processed by a conventional ladder network, and current-to-voltage transformation is made by an on-chip amplifier. This conventional D/A converter yields sine waves of sufficient purity that they require little or no filtering. The same amplifier accomplishes summing of the low and high group tones to obtain the required dual tone signal. ◈

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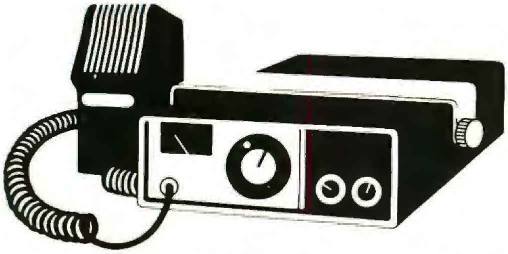

CB Scene

By Ray Newhall, KWI6010

IS CLASS E DEAD?

MY FEBRUARY column touched briefly on "Class E," a proposed new division of the Citizens Radio Service, first suggested in 1968 by the Electronic Industries Association. My mail bag tells me that I touched a tender nerve with at least a few of PE's "Ham" readers. Some letters have been in polite disagreement, but others contained emotional outbursts claiming that undisciplined CB'ers will soon blanket the entire radio spectrum with illegal linears. All responses were from radio amateurs who oppose any further expansion of the Citizens Band because CB'ers have abused Class D and have not "earned the right to use two-way radio."

I believe that the vast majority of the licensed CB'ers today are decent, law-abiding citizens who should not be spoken about in such a manner. Most use CB to conduct their personal communications, and, when needed, to help others. There are many more CB mobiles cooperating with law enforcement officers than those who try to harass them.

What Is Class E? As originally proposed by the EIA, Class E would consist of FM communication in the vhf region (specifically, on the lower 2 MHz of the 220-to-225-MHz band currently assigned to Amateur Radio). There would be a total of 80 channels, most designated for specific uses (mobile, in-plant, road condition information, etc.). The Class E band would be very similar to the new vhf-FM Marine band, but personal communications could be conducted on it between your vehicle and home or office. That type of communication is not permitted on Marine frequencies.

Unlike Class D, it would be nearly devoid of skip, heterodynes, and ignition and other types of noise. Above 100 MHz, nearly all radio propagation is "line of sight." That is, once the radio wave reaches the horizon, it merely flies off into space rather than bouncing off the ionosphere and returning to the earth as skip. Hence, more output power could be authorized for reliable communications without disturbing distant stations.

Another advantage is the FM "capture effect." An FM receiver will track the most powerful signal it receives, and suppress weaker ones on the same channel. In practice, you could either make solid contact or none at all. Between calls, the speaker is fully squelched and silent. FM lends itself to both tone-encoded squelch systems and phone patches, as Amateur practice on the 2-Meter band has demonstrated.

The original intent of the Citizens Radio Service was to provide short-range personal or business communication to any citizen. It was expected that most would use it between their cars or boats and homes or offices. (In keeping with that idea, only members of the licensee's immediate family or his direct employees can operate under the authority of his license.) Most important, CB was intended for those people who have no specialized technical knowledge or experience. Finally, the original CB concept excluded "hobby" operations (use of a CB radio for rag chewing, skip chasing, etc.)

Unfortunately, the inherent characteristics of AM signals and the 11-Meter band defeated these intentions as soon as the Service was established. It simply wasn't suitable for short-range, personal use, and many operators were hobbyists who got their "kicks" trying to pick out signals between the heterodynes, diathermy, and skip transmissions! Is it any wonder that manufacturers soon made linears available to anyone with the money to pay for them, and that Class D became the bandit band? How could anyone ask his wife or secretary to listen to that pandemonium all day while waiting for a call?

Would Class E Be Disciplined? I don't believe Class E would be abused as Class D has been, primarly because it would not attract the hobbyist who wants to DX half way across the country. Linears would not be any major advantage because enough power would be authorized (10 to 25 W) to put out a solid signal to the radio horizon. Also, a large increase in power (bootlegging it) would not boost effective range.

As it became popular, I believe the vhf band would be used by motorists just as they use the Class D band now. Safety and motorist assistance is a legitimate personal use, but in the Class E proposals to date, highway use would be restricted to relatively few channels. All transmitters should be of high quality and be rigidly controlled through type acceptance and mandatory periodic inspections. Automatic transmitter identification would enhance both regulatory powers and respect for FCC Regulations. It would also make the organized larceny of equipment far more difficult.

We must consider the radio spectrum as much a resource as air, water, coal, or petroleum. It must be conserved, but it must also be shared. The right to use it by the ordinary citizen cannot be refused because a minority has abused it. Do we close the beaches to the public because some thoughtless persons throw trash about? Do we refuse to issue new driver's licenses because some persons already licensed drive rather recklessly at times?

It is true that Class D privileges have been badly abused by a minority of users, but the overwhelming majority of licensed CB'ers try to operate their rigs legally. (I don't consider the unlicensed ones CB'ers — they would even drive their cars without a license if they thought they could get away with it!) Many legitimate operators have equipped their mobiles with CB just for the added safety it offers. I have noted that it is usually the newcomers on the band who show their exuberance by transmitting "Smokey" reports. But the band is maturing. Now, many truckers use their rigs more to assist law-enforcement agents than to try to "spot" them.

Where Do We Stand Today? For the moment, Class E is seemingly at an impasse. While the FCC recognizes

the justification for this new vhf-FM service, authorization has been temporarily blocked by Canada and Mexico by virtue of international treaties to which the U.S. is a party. Since our government cannot guarantee that the use of Class E transmitters by our citizens in border areas will not disrupt *their* use of these frequencies, those governments have refused to permit changes in the existing treaties which currently do not allow a Citizens Radio Service in this band.

There is also concern in this country that Class E would interfere with government radio-location services which share the 220-MHz band. And understandably, radio amateurs are cool to the ideal of Class E if it means losing 2 MHz of their spectrum allocations.

However, there are alternative courses of action the FCC could take. For example, it could allocate Class E a portion of the spectrum in which it would not conflict with the international treaties. Or it could try to negotiate a change of our neighbors' attitudes. It's not surprising that the Canadians are apprehensive, since they have experienced difficulties in controlling their own CB service.

Are The Objections To CB Valid? If CB is judged by traditional values, the radio amateurs who wrote to me are justified in their criticism of CB. But I feel that many of the traditional "ham" values may no longer be valid. Although some hams are experimenters and make contributions to the technical advancement of radio, they cannot compete with government and industry financed R & D. Most hams no longer build their own equipment, and are mainly interested in communicating. Of course, their oustanding efforts in times of natural and man-made disaster are well documented.

Admittedly, their frequency allocations have been eroded, and the 11-Meter band was taken from them to set up the Class D band. But amateurs still hold 46.5 MHz of the entire spectrum below 450 MHz. We CB'ers do not begrudge them their 10.3% of the hf, vhf, and low uhf portion of the spectrum, but we do feel that it is a bit unfair when some of 285,000 amateurs complain so bitterly about the greater than four million licensed CB'ers who are crowded into less than 0.5 MHz of spectrum, and who want just a bit more!

However, there is one important thing to keep in mind — CB and Amateur Radio *are* compatible! Although there have been strained relations in the past, more and more amateurs and CB'ers are getting to meet each other. They often find that the prejudices on both sides are not reflected in reality. Today the CB'er is not a "frustrated ham," but the guy down the block who uses radio for personal communications, not hobby operating. Evidence of this change of heart on the part of radio amateurs lies in the editorials of *QST* and *ham radio* for April, 1976.

Local amateur and CB clubs can work together to set up emergency communication systems, operator training sessions, etc. It is in the best interest of *both* services that there be mutual understanding and appreciation for the potentials of each group. So let's put aside any hard feelings and work together for our common goal — the efficient and proper use of frequencies allocated for individual use by private citizens, be they radio amateurs, CB'ers, or both!

To this CB-er, the facts are plain. One of every 30 Americans uses CB today. We represent a fair share of our country's total population. Collectively, the people are the ultimate authority under our Constitutional system. I believe that the Federal government should not deny us orderly and proper access to any of our nation's natural resources, including radio communications. I believe that the FCC *must* place a high priority on finding and allocating a suitable portion of the radio spectrum below 450 MHz for the personal use of the public.

Things to Come: The FCC is now considering a Citizens allocation in the vicinity of 910 MHz, twice the frequency that I consider the upper limit for practical use by citizens who have little or no technical competence in radio communication. I believe that that choice of frequencies would be as ill-advised as the original allocation of 27 MHz for Class D. The experience with the uhf Class B service only confirms my opinion. It was never accepted by the public as a viable frequency allocation and was eventually withdrawn. Equipment suited to operate at 910 MHz would be very expensive. Furthermore, I think it is ludicrous to consider an allocation which requires installation and maintenance support facilities that are beyond the means of most two-way radio service establishments now in existence. All in all, that frequency region is totally unsuitable for allocation to the Citizens Radio Service.

The intent of this article is to lay Class E right on the line. I, for one, am acutely aware of the need of many thousands of citizens who have a need for high-quality, personal two-way radio, but who are *not* radio hobbyists. These people are not yet on the CB rolls and cannot be counted. They have not yet been offered a service which meets their needs.

We should all write and urge the FCC to continue its search for an adequate frequency allocation for a service such as it had in mind when Citizens Band was first authorized. Our citizens deserve no less than a first-class service with all the facilities that modern technology can provide. That includes private call facilities (tone-encoded squelch), phone-patch facilities, direct public service and correspondence channels, and possibly repeaters. However, along with these added privileges should come a strictly enforced system of equipment standardization, including a periodic inspection program such as most states have for motor vehicles.

I recommend the annual licensing of all transmitters, with the requirement of annual inspection before renewal. I support automatic (on-the-air) transmitter identification. There is no reason why the legitimate operator should fear it, and ATI will enhance enforcement of channel usage restrictions and reduce equipment theft (by making it more difficult to "fence" stolen CB equipment). I also believe that the FCC charter should be extended by the Congress to include new minimum receiver standards. This new aspect of the law would protect CB users as consumers, and would protect the public as a whole against TV and other receivers with insufficient off-channel rejection characteristics.

Class E would be a different service than Class D, and would draw a different group of licensees. In no way do I suggest any reduction in the Class D service, which has its own separate and useful function.

As usual, I invite comments, but I cannot personally answer all letters. I particularly would appreciate comments from the CB community, or those who would use Class E if it were authorized as I propose. ◈

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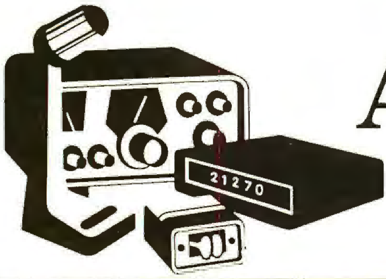

Amateur Radio

By Herbert S. Brier

LIGHTNING AND THE RADIO AMATEUR

MOST OF US are familiar with the indirect effects that lightning produces on amateur communications—tremendous static crashes can make 80 Meters (and above) almost unusable on some summer nights. But every so often, we hear of the direct consequences of a lightning strike at an amateur's station. Among the reported effects are vaporized antenna elements, burned-out rotator motors, melted insulation in control and coaxial cables, and fused conductors.

Inside the shack, a number of things can happen. The antenna coils in the receiver can melt, or the contacts on the band switch weld together. Tubes and transistors can be destroyed. Diodes and capacitors, especially in the power supply, can blow. From the outside, the rotor control box might look fine, but it can be a shambles of burned out and shorted components on the inside. Half the lights in the house might be blown, and the rest will glow whether they are switched on or off. Electrical receptacles can be blown half out of their wall boxes. If a fire ensues, the firemen can do as much damage ripping out equipment and cutting cable as the original lightning strike caused.

This type of damage that has been experienced by amateurs whose antennas were struck by lightning does *not* mean that an outside antenna invites disaster in an electrical storm. On the contrary, a properly installed antenna is said to create a "cone of protection" whose diameter is approximately equal to the height of the antenna itself. Many amateurs have operated for years and years with antennas that are the highest objects in the vicinity of their homes without lightning damage (Fig. 1).

The secret of protecting antennas and the equipment connected to them is to provide a direct path from the antenna to the earth so that the electrical charges picked up from the atmosphere will be discharged harmlessly into the earth, rather than blasting a path to the earth through the equipment to which the antenna is connected. The most familiar static discharge units (popularly called "lightning arrestors") are inserted in the feedlines of TV and radio receiving antennas and are grounded at the point where they enter the building. The units are usually miniature spark gaps. The weak received signals flow past the gap without difficulty, but high-voltage static charges jump the gap and are diverted to the earth. Coaxial units with trade names such as "Blitz Bugs" can be connected in series with a coaxial cable. They are usable in transmitting applications when the SWR on the line is not too high. However, they are not really necessary when a properly-installed coaxial line is used with a dc-grounded antenna. A typical homemade arrestor for open-wire line is shown in Fig. 2.

If coaxial cable is used to feed an antenna, the National Electrical Code's provisions for lightning protection are met by connecting its shield directly to ground where the cable enters the building. One method of doing the job is to mount a type *83-1F* or *UG-363/U* coaxial "bulk adapter" on a corrosion-resistant metal bracket just outside or inside the opening through which the cable comes into the radio room. Connect the coaxial cable from the antenna to one end of the *83-1F* adapter using a PL-259 connector on the cable, and the cable from the transmitter to the other end. Clamp the bracket to a ground electrode through a heavy conductor running in as straight a line as practical.

Ground Conductors. The N.E.C. specifies that a ground conductor must have a minimum cross-sectional area at least as large as *all* conductors being grounded through it. In any event, it should not be smaller than *No. 10* and should be composed of copper, bronze, copper-clad steel, or equivalent. The conductor may be bare or insulated and should be protected from mechanical injury. It should go to the ground electrode in the shortest practical path with no sharp bends. Otherwise, the heavy current flowing through it during a lightning strike may ionize the air at

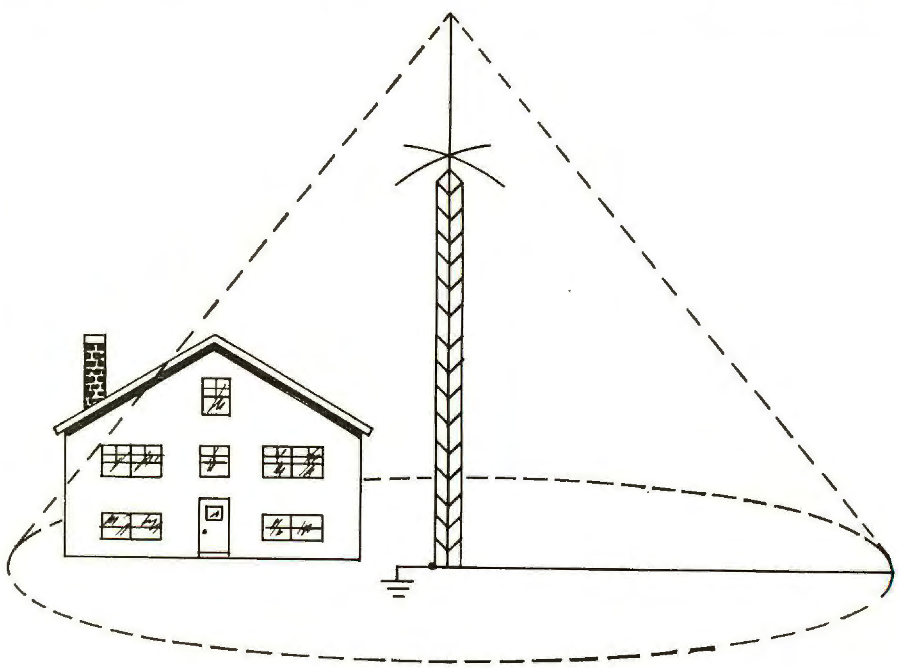

Fig. 1. Grounded antenna and tower create "cone of protection" for nearby structures.

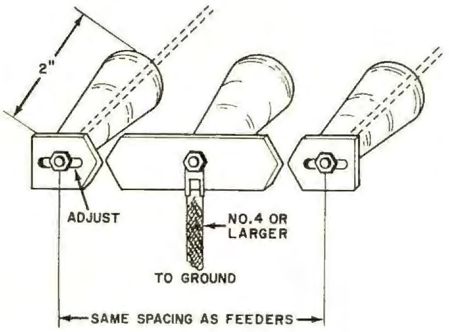

Fig. 2. Spark-gap lightning arrestor for feedline.

the bend and leave the conductor at that point to find its own path to ground, doing much damage in the process.

When available, a metal underground water pipe should always be used as the ground electrode, regardless of its length; however, if its underground section is (or is likely to be) less than 10 feet in length, it should be supplemented by an additional grounding electrode. This electrode can be a heavily galvanized iron or steel pipe a minimum of 1.25 inches, outside diameter, a ½-inch copper rod or other approved ground electrode driven into the ground a minimum of eight feet. Such a driven electrode can replace the buried, water-pipe ground, if the latter is unavailable. If the soil is dry and sandy, two or more driven electrodes spaced a minimum of six feet apart and bonded together can be used to achieve a lower ground resistance. In fact, all available ground electrodes should be bonded together to lower the ground resistance as much as possible.

It's interesting to note the differences in ground systems for lightning protection and a buried radial system for a vertical antenna's ground plane. The former uses electrodes driven or buried deep in the earth; the latter is burned only a few inches. There is no objection to connecting the ends and centers of the radials for additional lightning protection, however.

Ground all supporting structures, including those mounted on roofs of buildings. Metal towers are usually adequately grounded, but run a heavy conductor to the hardware at the top of a wooden structure supporting a horizontal antenna to the ground electrode. If the mast supports only a wire antenna, extend a metal rod a foot or so above its top as a lightning rod. Any elevated "ground plane" radial wires and the shield of the coaxial feed line should be grounded before adjusting the antenna to the desired operating frequency. When the feed point of the vertical radiator is isolated from the radial system, a coaxial static discharge unit ("Blitz Bug") may be inserted between the PL-259 connector and the feed line to help drain static charges off of the vertical radiator of the antenna.

Unfortunately, grounding a multiband "trap" antenna at the feed point does not protect its traps from high-intensity static currents in the event of a strike. The obvious solution to the problem is a spark gap across each trap, adjusted to the minimum spacing that does not arc under normal operation. However, many amateurs would merely repair or replace the trap if it is damaged by lightning.

Inside The Shack. For maximum safety, bond all metal cabinets, microphones, keys, and control boxes to a common ground bus. Homes built in the past few years or so often contain 3-terminal wall outlets with the third (round) terminal connected to the grounded neutral point of the power line. By using appropriate power cords with the third conductors connected to all chassis, they will be automatically grounded as the power plug is inserted in the receptacle.

I wish I could say that these suggestions guarantee that lightning will never damage any of your equipment. The sad truth is that a lightning strike or near miss creates such a high-energy field in the vicinity that induced voltage spikes up to several thousand volts have been measured on local power lines during severe electrical storms. Occasionally, these surges find their way to ground through equipment plugged into the lines, popping components in the process. Cautious operators pull the power plugs and disconnect their antennas whenever a bad storm is brewing, or when they leave their equipment unattended. If you decide to follow their lead, don't just disconnect the antenna lead-in and leave it lying on the floor. Whether connected or disconnected, the only safe conductor in a storm is a grounded conductor. If your antenna selector switch grounds all positions except the one in service, turn the switch to an unused position whenever you leave the room. Finally, don't forget to unplug the rotor control cable and plug it into a socket with all terminals connected to the main ground electrode. ◈

Electronics Library

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by Michael Robbins

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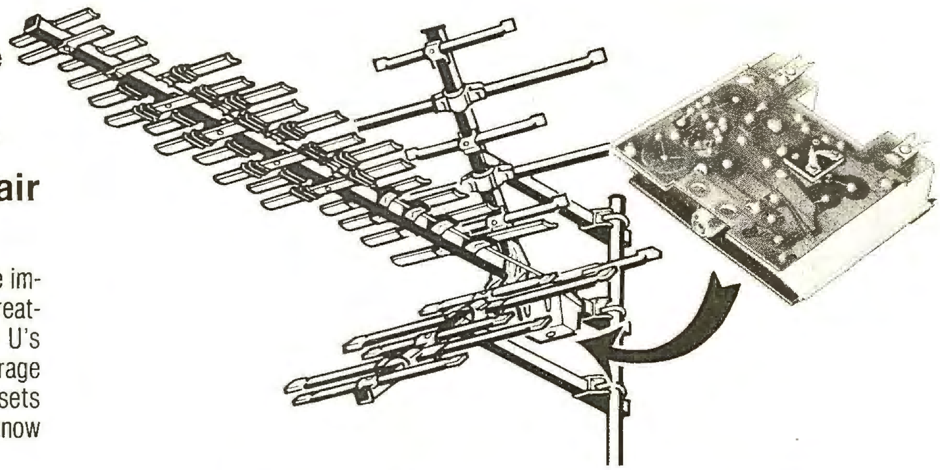

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BANDPASS (MHZ) VHF-FM UHF	54 to 216 470 to 890
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NOISE FIGURE UHF	2.2db

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Now Winegard Company is introducing another...and even bigger breakthrough. This is a super lo-noise UHF preamplifier, Model AC-4990.* It has a 6db signal-to-noise improvement over the best UHF preamps previously available.

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Vendo Co. type ID-169B/APN-12 indicator. **Federal Telephone and Radio** AM-6/APA-1 and GFT-20209 power unit. Schematics and any other info. Steve Swift, 7807 218th SW #54, Edmonds, WA 98020.

AMI Model JKB-100 jukebox. Service manual. Need power transformers: **Stancor** P-1501, P-1503, P-4045 to P-4049, **Thordarson** T-22R08 to T-22R11, **Merit** P-2965 to P-2968. **Dumont** Model 180 TV parts needed. Jim Farago, Box 335, S. St. Paul, MN 55075.

NRI Model W VTVM. Instruction manual, data on transformer and diodes. David Vescovi, 119 North St., Box 7, Walton, NY 13856.

Echophone Commercial radio (3-band), serial EC-3305. Schematic, wiring, and parts placement diagrams, or any helpful information. Allen Fryou, 3735 Fairmont Dr., New Orleans, LA 70122.

Crosley Model 127-1 "Happy Hour" receiver circa 1931. Schematic needed. **Rider** Radio Schematics book Volume 1 or copy. John Fritz, 645 Wyncroft Lane, Lancaster, PA 17603.

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Capehart Model 8T-71 AM/FM/8-Track, serial 710800084. Power transformer data or source for same. Robert Wong, Lagoenweg #15, Oranjestad, Aruba, Netherlands Antilles.

Dumont Model 241 oscilloscope. Instruction manual and/or schematic. William Stockman, 224 E. 36th St., New York, NY 10016.

Miranda Nocturne stereo tape recorder. Schematic and any other information. Walter Baker, 162 N. Queens Ave., N. Massapequa, NY 11758.

General Electric LBI-3401 12-volt mobile transmitter/receiver unit. Need two control head cables. Jeff Saulich, 3418 W. Lee Street, Pensacola, FL 32505.

Victoreen Mod. 356 Alpha Survey Meter. **Sanborn** Model 299 dc amplifier/recorder. Instruction manuals and schematics. William J. Olson, 14614 Figueras Rd., La Mirada, CA 90638.

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Philco Model S8202 oscilloscope. Schematic, parts lists, power transformer or substitute needed. S.B. Hall, 203 Cedar Ave., Sharon, PA 16146.

Telectro Industries Model TR-2120 recorder, TA-1496 playback amp., TA-1362A record amp., TC-2079A control unit, and TS-2059. Schematics or manual. G.A. Robertson, 5551-A Orcutt Ave., Apt. E, Newport News, VA 23605.

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U.S. Govt. ARC-5 receiver. Need conversion information and schematic for bc band (.52-1 5 MHz) ET1. S.J. Floroski, USN, Box 60, USNRTF, FPO, NY, NY 09544.

McGee Radio Co. (Kansas City, MO) Miniature Broadcasting Station schematic. Years needed: 1945, '48. Daniel Schlitt, Vine St., Jacksonville, IL 62650.

Experimenter's Corner

By Forrest M. Mims

THE 567 TONE DECODER

THERE ARE many applications for circuits that can be made to respond to a specific tone frequency while ignoring all others. Some of these include radio controlled garage door openers and model airplanes, automatic paging systems, intrusion alarms, communications systems, and highly secure electronic locks.

Over the years, several practical circuits which respond to a specific tone frequency have been designed. Two of the best known are the resonant reed relay, once very popular with radio control modelers, and narrow bandpass active filters using one or more operational amplifiers.

The arrival of sophisticated single chip phase-locked loops (PLL's) a few years ago has made possible a variety of versatile tone-detection circuits, the 567 being designed especially for this role. Supplied in either an 8-pin mini-DIP or TO-5 can, the 567 is available from several sources listed in the Electronics Market-place in this magazine for less than $1.75.

The functional block diagram of the 567 tone decoder is shown in Fig. 1. The circuit incorporates 62 transistors to provide synchronous AM lock detection and a power output stage. In operation, a current controlled oscillator (cco) operates at a frequency determined by external components *R1* and *C1*. This frequency is called the center frequency (f) and is equivalent to 1.1/*R1C1*. Both the input and the cco signals are fed into a pair of phase detectors. When the input frequency falls within the detection bandwidth of the circuit (0 to 14% of f), an output transistor capable of sinking up to 100 mA turns on. The output can directly control miniature lamps, relays, and LED's.

The 567 is an incredibly flexible chip with many different operating characteristics and capabilities. For example, it has a tone detection range of from 0.01 Hz to 500 kHz and will lock onto a signal with an amplitude of only 20 mV rms! Operating voltage ranges from a TTL-compatible 4.75 volts to a high of 9 volts. Standby current consumption is a reasonably low 6 to 10 mA, while activated current consumption without load is 11 to 15 mA.

Experimenter's Circuit. I think the best way for you to relate to the 567 PLL is to try it in an actual circuit, such as shown in Fig. 2. This circuit is a straightforward tone decoder with a built-in variable-frequency oscillator made from a single 555 timer.

The 555 is operated in its astable mode to produce square shaped output pulses. The repetition rate of the 555 is controlled by *R4* and *C5*. Increasing the values of *R4* and *C5* slows the repetition rate, while decreasing

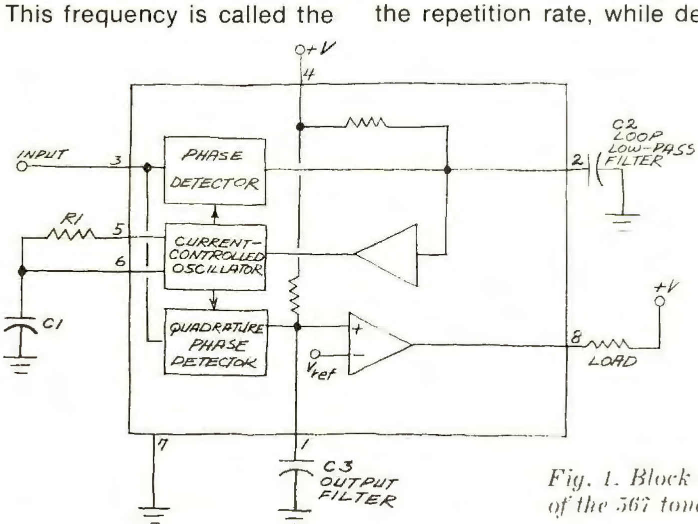

Fig. 1. Block diagram of the 567 tone decoder.

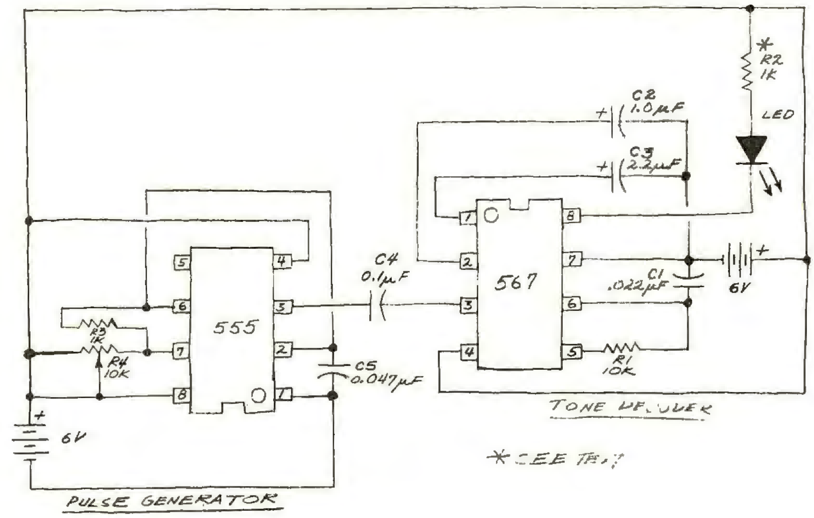

Fig. 2. Tone decoder demonstration circuit.

values speeds up the repetition rate.

With the component values given in Fig. 2, f should be 5000 Hz (1.1/10,000 × 0.022 × 10^{-6}). The test circuit, however, gave an f of 4480 Hz. I measured *R1* with a digital multimeter and found its actual resistance to be 10,320 ohms. This new value gave an f of 4845 Hz, which is within 3% of the predicted frequency, and any error is traceable to the tolerance of *C1*.

After you put the circuit together, experiment with the adjustment of *R4* while watching the LED. The LED should turn rapidly on and off as you rotate *R4's* shaft past the point where the 555 oscillates at the f of the 567. If you dim the room lights, you may notice the LED flickering just before and after it turns full on and off. Resistor *R2* limits LED current to about 3.5 mA. If your workbench is brightly illuminated or your LED inefficient, you can reduce the value of R2 (say, to 500 ohms) to get more current through the LED. In any event, be sure to use a regulated dc supply or fresh batteries.

Frequency Response. A graph showing the response of the circuit in Fig. 2 in the acceptance bandwidth region is shown in Fig. 3. The graph shows the input frequency from the 555 versus the output current through the LED. Note that the bandwidth is fairly wide when the input frequency goes high to low and vice versa.

After you've tried changing the frequency of the input tone, replace *R1* of the tone decoder with a 2000-ohm fixed resistor in series with a 20,000- or 25,000-ohm potentiometer and readjust *R4* to provide an unknown input tone. You should easily be able to lock onto the unknown input frequency by adjusting the potentiometer. You can arrive at a rough estimate of the frequency of the unknown tone *without* using a scope or counter by measuring the total resistance of the potentiometer and its 2000-ohm series resistor and using the center-frequency formula.

At this point, the 567 would appear to work just fine, since it triggers an LED in response to any desired tone. But if you actually build the test circuit, you'll soon discover that the 567

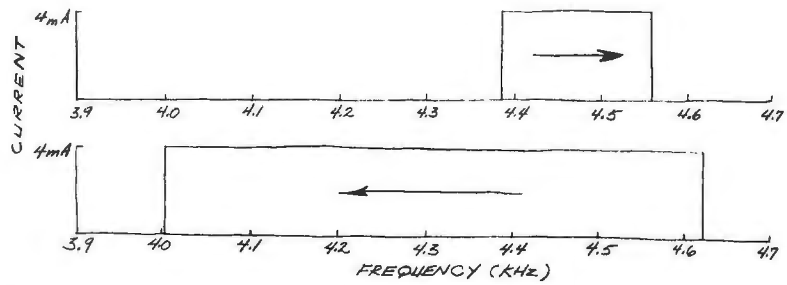

Fig. 3. Frequency response of circuit in Fig. 2. Arrows indicate positive and negative frequency changes.

has a tendency to trigger on what appear to be harmonics of the center frequency. The 567 will, in fact, lock onto frequencies corresponding to input signals near f_t (4n + 1) (where n = 0, 1, 2, 3 . . .). Also, the square pulses from the 555 will cause an output for f /2.

Fortunately, the response of the 567 to tones other than f_t is usually of no consequence. And if false triggering to undesired tones becomes a problem, you can either change the center frequency of the 567 or attenuate the offending tone with a notch filter.

Other Applications. After you have experimented with the 567 using the basic circuit in Fig. 2, you will probably think of lots of interesting applications. One fascinating possibility is a secret photoelectric lock activated by a tone-modulated LED. A phototransistor connected to the input of the 567 can be used to receive the signal from the LED, as shown in Fig. 4. This circuit has an optical range of a few centimeters without external lenses at either the LED or phototransistor. This is all the distance you need for most lock applications, but for more range you can add an amplifier between the phototransistor and the 567 and use a lens at each end.

Whether checking out a potential application or just for fun, don't hesitate to experiment with the basic 567 circuit in Fig. 2. For best results, Signetics recommends that the resistance of R1 be between 200 and 20,000 ohms. Capacitor C2, the loop low-pass filter, should be selected from the Bandwidth versus Input Signal Amplitude graph given in both the National and Signetics data sheets on the 567.

At very low input frequencies, the time required for the 567 to lock onto the input tone can become relatively long. For example, I found that an input tone of 500 Hz required a full second for lock to occur. These and other eccentricities of the 567 are covered in detail in the manufacturer's (Signetics) data sheet, and I urge you to obtain this well-prepared document to assist you while experimenting with the 567. Another excellent source of information on the 567 is found in the Signetics Digital/Linear/MOS Applications book (Section 6, "Phase Locked Loop Applications"). ◈

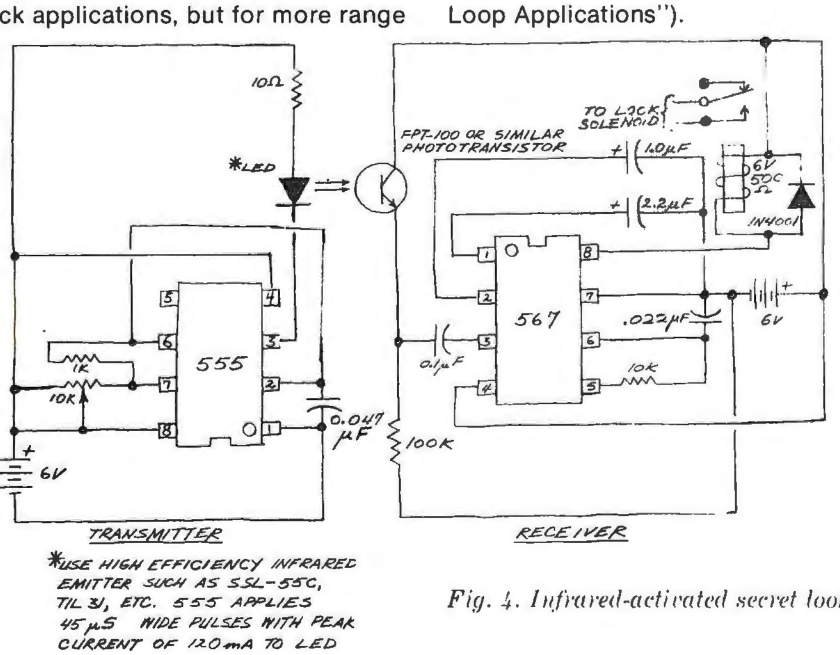

Fig. 4. Infrared-activated secret lock.

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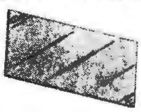

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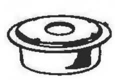

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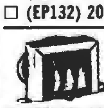

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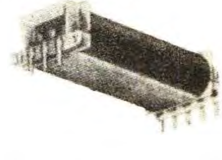

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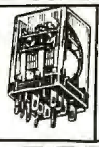
SEND A STAMP FOR OUR FLYER LISTING MORE BARGAINS!!

3 Amp Power Silicon Rectifiers
MARKED AXIAL PACKAGE

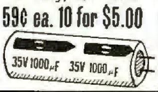
PRV	EACH	PRV	EACH
50	$.08	600	$.24
100	.13	700	.27
200	.15	800	.30
300	.18	900	.40
400	.20	1000	.50
500	.22	1200	.60
		1400	$.70

POTTER BRUMFIELD
Type KHP Relay
4 PDT 3A Contacts
24V DC . . $1.50 (650 coil)
120V AC. . $1.75 (10.5 MA coil)



Memories
93410-256x1 RAM, fully decoded, high speed (40 ns) open collector output. 16 pin DIP with data.
$1.75 each
10 for $14.95

Capacitors
PCB vertical mount electrolytic capacitors. 2" long, 3/4" dia.
59¢ ea. 10 for $5.00



Mail orders to:
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Sacramento, CA 95841
Phone (916) 334-2161
TWX # 910-367-3521

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All IC's are new and fully tested. Leads are plated with gold or solder. Due to increased costs, orders under $7.00 add $1.00 postage and handling. Residents of California add sales tax. Orders shipped promptly. $10 minimum order on C.O.D.'s.

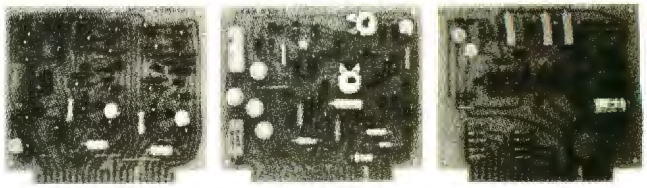
TTL

7400	$ .20
74H00	.25
7401	.14
74H01	.25
7402	.25
7404	.25
74H04	.30
7405	.30
7406	.40
7408	.30
7410	.12
7413	.75
7417	.40
7420	.12
74L20	.25
74H20	.18
7430	.10
74H30	.30
74L30	.30
7440	.10
74H40	.22
7442	1.00
7447	1.50
7450	.10
74H50	.30
7451	.10
74H51	.25
7453	.10
74L54	.25
74L55	.25
7460	.15
74L71	.20
7472	.40
74L72	.60
7473	.35
74L73	.75
7474	.45
74H74	.75
7475	.80
7476	.35
74L78	.70
7480	.50
7483	.70
7489	2.00
7490	.70
7492	.35
7493	1.00
7495	.65
74L95	1.00
74107	.25
74123	.75
74145	1.25
74155	.90
74174	1.00
74180	1.00
74192	1.00
74193	1.00
75492	1.00

DELTA ELECTRONICS CO.

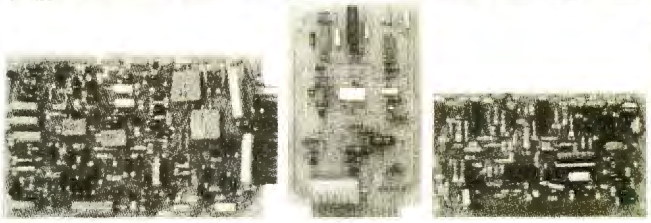
P.O. BOX 2, AMESBURY, MASS. 01913

PC BOARDS



This set of boards has a wealth of small parts useful for many projects. The boards have 32 transistors, including 6 complimentary pairs and a UJT, 6 zener diodes (5.6v, 2 6.8v, 8.2v, 12v, 15v), and 33 rectifier diodes, 100v to 600v, 1 amp to 3 amp ratings. Also 3 trimpots, a Varistor, and many resistors and various caps, 2 SCRs.

STOCK NO. P5398 2 lbs. 3 board set $3.00, 3 sets/$8.00



Another board set with many good linear parts. Has (5) 741 and (1) 709 op-amps in DIP packages, 19 transistors including 6 complimentary pairs, 31 diodes (rectifier, switching, & zeners), 5 multi-turn trimmers, and many good electrolytics, precision resistors, ¼ & ½W resistors, etc.

STOCK NO. P5399 2 lbs. 3 board set $4.00, 3 sets/$11.00

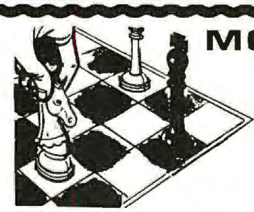
Send for our free catalog. Phone orders welcome. MASTERCHARGE & BANKAMERICARD accepted. ALL numbers must be included to process order. Minimum order $5. Include sufficient postage; excess will be refunded.

Phone (617) 388-4705

CIRCLE NO. 18 ON FREE INFORMATION CARD

MSI

Wise move

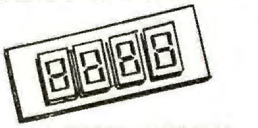


MODULAR SCIENTIFIC INSTRUMENTATION

Now you can build some of the most advanced digital electronic instruments with our new series of low-cost modular scientific kits. These kits will expand the range of your electronic applications enormously--and all at a surprisingly low cost.

The heart of the system is our 4-digit Decade Counter (Kit 012) which features a full 4-digit LED readout (you choose the size best suited to your application). Combine this with a 5-volt regulated power supply (Kit 030) and you have the basis of a wide range of sophisticated electronic instruments, including:

A Digital Voltmeter (DVM)	Kit 012 + Kit 030 + Kit 017
Frequency Counter	Kit 012 + Kit 030 + Kit 016 +Time Base
RPM Counter	Kit 012 + Kit 030 + Kit 020 + Kit 018



4-DIGIT DECADE COUNTER KIT
$19.95
KIT 012

One chip 4 digit decade counter kit, with both 7 segment and BCD output.

1. Chip features internal oscillator for scanning speed.
2. Overflow and count extent outputs.
3. Transfer, reset, count, blanking and true compliment control inputs.
4. PC Boards can be cascaded to 8-12-16, etc. digits.
5. Kit includes counter chip, drive circuit for 4 cathode type displays and PC Board. (For readout board see (FND70-FND503)

KIT 016 FREQ. COUNTER

Features FET input front end with trigger circuit for measuring complex waveforms. Measures from 0.1Hz to 10MHz when used with Kit 015 or 019. Measures from .01Hz to 35MHz when used with Kit 013 and 014. **$24.50**

KIT 017 DVM

1.999V as basic, with polarity indication. 1 M ohm input impedance and accuracy to 1% if properly adjusted **$13.50**

KIT 020 RPM COUNTER

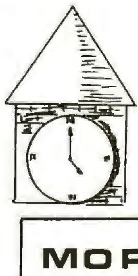
Counts from 1 to 100,000 RPM. RPM counter kit contains components and PC board. **$8.95**

KIT 030 POWER SUPPLY

*Input voltage: 25V max. *Output current: 1 amp max. *Load regulation: 50mV. *Output voltage: 5V. *Line regulation: .01%. (requires 8-20V transformer) **$4.55**

(Contains all parts except transformer)

TIME BASES



1 Mhz crystal chain time base divider. Outputs; 1Mhz-100Khz-10Khz-1Khz-100Hz-10Hz-1Hz-0.1Hz. Accuracy better than .005% with proper adjustment.

Kit 013 complete CMos with PC board $15.75
Buffer Circuit for TTL Interfacing

Kit 014 Same as Kit 013, but with TTL.......... $13.75

Kit 015 50Hz or 60Hz chain time base using line frequence as reference. Accuracy 0.1-0.05%. Outputs 10Hz-1Hz-0.1Hz. Complete with CMos shaping circuit and PC Board.......... $9.75

Kit 019 Same as Kit 015, but with TTL and 60Hz only.......... $7.75

Kit 018 60Hz chain time base using line frequence for Kit 020 RPM counter.

*Outputs: .6 sec. = 100th of RPM
6 sec.= 10th of RPM
60 sec. = full revolution

$9.75

MORE TO COME

Watch this space in future issues for additional kits, including Multimeter, Timer, Capacitance Meter, Thermometer and many more. With our kits and your imagination, you'll find dozens of new and exciting applications.

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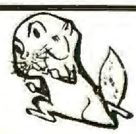


WE ARE EAGER TO SERVE YOU!

CIRCLE NO. 7 ON FREE INFORMATION CARD

HP7730
.33 in. high red
very bright
25mA per seg.
Common anode.
$1.20

DL727
One of our best readouts
.5 in. high, 20mA per
segment. Common anode.
$3.75

FND 807 ANODE
FND 800 CATHODE
.8 in. High. The Best
on the market. Ideal
for large readout
application. $4.95

FND 503
$1.60
5/$7.50
New .5 in. display
by Fairchild.
Common Cathode.

.25 in high orange
digit. 160v dc.
Free socket. $2.50
BURROUGHS
12 DIGIT

LEDS

Mini red	.12
Jumbo red	.15
Jumbo green	.20
Jumbo yellow	.25

TI
Fully multiplexed common cathode.
Goldplated. Idea for mini 6 digit
clock. $1.30

DL33
If you like an
array of displays,
we have it. Common cathode.
$1.45

4 & 6 DIGIT PC BOARDS

PC Board for 4 digit display FND 800 or 807	$2.75
PC Board for 6 digit display FND 800 or 807	$3.50
PC Board for 4 digit display MAN series or DL707	$1.75
PC Board for 6 digit display MAN series or DL707	$2.25
PC Board for 4 digit display FND503	$2.00
PC Board for 6 digit display FND503	$3.00
PC Board for 4 digit display DL747	$2.50
PC Board for 6 digit display DL747	$3.00
PC Board for 4 digit display DL727	$2.25
PC Board for 6 digit display DL727	$3.00
PC Board for 4 digit display FND70	$1.75

All PC display boards are multiplexed for adding additional digits.

$$$ SAVE! 4-DIGIT ALARM CLOCK

KIT NO.1 $13.95
(with PC Board)

FEATURES:

Direct drive display outputs, * Current control regulation-on chip, * Low power brightness control-on chip, * RFI eliminating slowup circuitry, * Sleep Radio feature, * 24 hr. snooze alarm, * Independent digit setting, * Non multiplexed output circuitry. 12VAC CT 1/2 amp transformer for Kit No. 1 $2.00

*KIT NO. 2

Complete kit with components, PC Board, Transformer, wood grain case and filter for display window. Includes .25 in. readouts.
$21.50

KIT NO. 3

Complete kit with components, PC Board, Transformer, wood grain case, and filter for display window. Includes .5 inch readouts.
$22.50

* Components for Kit No. 2 or Kit No. 3 sleep radio feature, add $.95

LSI INTEGRATION

MM5316 -	4-6 digit alarm clock 40 pin dip w/spec	$ 4.25
7002 -	4 digit counter/latch decoder; 7 segment and BCD outputs. 28 pin dip w/spec	$12.50
7005 -	4 digit counter/latch decoder; 7 segment output only. 24 pin dip w/spec	$ 9.50
7007 -	4 digit counter/latch decoder with BCD output only. 16 pin dip w/spec	$ 7.00
70250 -	4-6 digit alarm clock 28 pin dip w/spec	$ 5.50
PC Board for70250		$ 4.25
70380 -	4 digit non-multiplexed radio alarm clock featuring direct drive display output 40 pin dip w/spec	$3.50
PC Board for 70380		$ 3.75
8008 -	8 bit parallel CPU	$19.50
2102 -	1K static RAM for 8008	$ 2.25
MM5203 -	2K UV eraseable PROM	$12.25
75491 -	segment driver	$ 0.35
75492 -	digit driver	$ 0.45
7020 -	6 function calculator chip with direct segment drive. 8 digit	$ 2.25

GE TRANSISTOR ASSORTMENT
T098 cased Darling., SCRs, NPN,PNP, ect.
50 for $0.95
100 for $1.75
300 for $5.00

TTL BOARDS

MEMOREX computer boards with TTL's Diodes and Transistors, etc.

5 Boards containing 150-250 IC's $3.95

GOT A CASE? HERE'S THE CURE!

Ideal for Frequency counter case function generator, etc. Overall height 4", length 12", width 7 1/2".

(Includes top, hottom, and hardware.)

$5.95

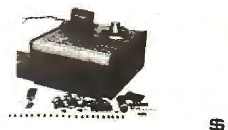
MASTER II

LIGHTS MUSIC

60 WATT COLOR ORGAN

Completely self contained unit with 120 volt power cord included.
$1.50

THE KING OF ALTAJ



6-DIGIT ALARM CLOCK

$23.50

THE KING FEATURES:

1) 6 digit, 12 hr. 60 cycle or 24 hr. 50 cycle alarm clock.
2) Time sharing capability for display of additional information
3) Single 12v. supply and a minimum of interface components.
4) AM-PM and automatic power failure indications.
5) 10 minute snooze
6) Intensity control of LEDs.

Kit No. 70250-1R (Red readouts)
Kit No. 70250-1G (Green readouts)
Kit No. 70250-1Y (Yellow readouts)
Kit No. 70250-2R (DL727 readouts) $28.50
Kit No. 70250-3R (FND807 readouts) $29.50

All kits include components, PC Boards, Transformer, case, and construction manual.

THE KING'S HAREM

FATIMA 4-DIGIT TEMP. KIT $19.95

Features 4-digit temperature display; farenheit or centigrade; complete C-Mos application; uses 7002 4-digit counter.

Kit includes all components, PC Board and instructions for interfacing with THE KING 6-digit alarm clock. Addition Number 1

DELILA APPLIANCE STARTER $9.95

(Example) Set your alarm for 7: a.m., set timer for 15 min. At exactly 7: a.m., the appliance will start; at 7:15 your clock alarm will wake you.

Kit includes all components, PC Board and instructions for interfacing with THE KING 6-digit alarm clock. Addition Number 2

TANYA 60HZ CRYSTAL TIME BASE $5.95

ADDITIONAL FEATURES:
1.) Low Power Consumption
2.) Directly Interfaces with King MOS Clock Chip.
3.) 60 Hz output with crystal time base accuracy
4.) Ideal for Cars, Boats, & Campers.

Kit includes all components, PC Board and instructions for interfacing with THE KING 6-Digit Alarm Clock. Addition No. 3

TTL

7400	-.21	7447	-.94	74151	-.80
7402	-.21	7448	-.94	74153	-.94
7404	-.21	7453	-.21	74154	-1.00
7406	-.29	7473	-.42	74161	-1.04
7408	-.21	7474	-.42	74163	-1.24
7410	-.21	7475	-.70	74164	-1.94
7413	-.54	7476	-.44	74165	-1.54
7420	-.21	7483	-.90	74174	-1.34
7427	-.29	7490	-.74	74175	-1.44
7430	-.21	7492	-.80	74181	-2,80
7437	-.44	7493	-.80	74192	-1.30
7438	-.39	7495	-.80	74193	-1.30
7440	-.21	7496	-.80	74195	-.84
7442	-.74	74121	-.43	74197	-.84
		74123	-.80		

CMOS

4000	-.24	4018	-1.49	4035	-1.39
4001	-.24	4019	.59	4037	-4.50
4002	-.24	4020	-1.59	4040	-1.59
4006	-1.49	4021	-1.49	4041	-.89
4007	-.24	4022	-1.19	4042	-.79
4008	-1.15	4023	-.24	4043	-.80
4009	-.59	4024	-.99	4044	-.59
4010	-.55	4025	-.24	4047	-.59
4011	-.24	4026	-1.49	4049	-.59
4012	-.24	4027	-.59	4050	-.59
4013	-.59	4028	-.99	4066	-.99
4014	-1.49	4029	-1.39	4077	-.39
4015	-1.19	4030	-.49	74C02	-.29
4016	-.59	4032	-.24	74C04	-.29
4017	-1.29	4033	1.49	74C107	-1.29
		4034	-3.25		

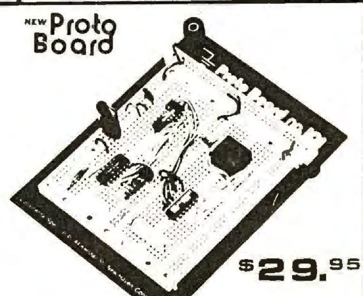
CONTINENTAL SPECIALTIES

THE ONE SOURCE FOR EVERYTHING NEW IN BREAD BOARDING

$19.95
(Complete Kit)

CSC 100

NEW Proto Board



$29.95

CSC 101

Write for our FREE Brochure

LINEARS

555 Timer Mini dip	0.65
8038 Functional generator	4.25
RCA 3043 FM If, Aud Preamp.	1.20
565 Phase Lock Loop	1.95
567V Tone Decoder	1.50
LM723 Pos. Volt. Reg.	0.55
LM309 5v. Lamp Reg'	1.10
LM380 2w. Audio Amp. 8 pin dip	1.00
LM741 Operational Amp.	0.25

TRANSISTORS-DIODES

RCA200V 115W T05 NPN		1.25
GE D40C1 NPN Darl.		0.25
2N4443SCR 400v8A T0220		0.65
2N2222 NPN Gen Ampl.		0.20
2N3904 NPN Driver		0.15
2N3906 PNP Compl. 2N3904		0.15
2N4400 NPN Low level noise		0.20
2N5401 PNP Nixie driver		0.25
1N4004	400PIV	15 for 1.00
1N4007	4000PIV	10 for 1.00
1N746	3.3 Zen.	4 for 1.00
1N4148	Switch	20 for 1.00

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Power Supply Kit: 5 Volt 1 Amp. Req.
Line regulation .005%
Load regulation 50mV

Kit includes Components, PC Board, Transf., Fuse, Pilot Light
Nothing else to buy: $5.50

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FREE: Send for your copy of our 1976 QUEST CATALOG. Include .13¢ stamp.

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Same day shipment
First line parts only. Factory tested. Guaranteed money back. Quality IC's and other components at factory prices.

INTEGRATED CIRCUITS

7400 TTL

SN7400N	17
SN7401N	17
SN7402N	17
SN7403N	17
SN7404N	19
SN7408N	23
SN7410N	17
SN7414N	63
SN7416N	34
SN7417N	39
SN7420N	17
SN7421N	37
SN7430N	17
SN7438N	25
SN7439N	25
SN7440N	17
SN7447N	60
SN7448N	78
SN7450N	17
SN7473N	36
SN7474N	32
SN7475N	49
SN7476N	44
SN7483N	70
SN7486N	41
SN7489N	2 00
SN7490N	45
SN7492N	45
SN7493N	65
SN7496N	75
SN74100N	1 10
SN74107N	39
SN74121N	39
SN74123N	59
SN74126N	45
SN74145N	89
SN74150N	95
SN74151N	1 10
SN74154N	1 10
SN74155N	95
SN74157N	95
SN74161N	95
SN74166N	1 35
SN74170N	1.95
SN74174N	1 19
SN74175N	90
SN74181N	2 40
SN74190N	1 15
SN74191N	1.25
SN74193N	85
SN74198N	1 65
SN74251N	1 60
SN74298N	1 65

74LS00 TTL

SN74LS00N	34
SN74LS02N	34
SN74LS04N	39
SN74LS08N	39
SN74LS10N	39
SN74LS20N	34
SN74LS28N	41
SN74LS30N	34
SN74LS38N	39
SN74LS74N	59
SN74LS75N	75
SN74LS90N	1 10
SN74LS93N	1 10
SN74LS95N	1.89
SN74LS107N	52
SN74LS132N	1 50
SN74LS139N	1 68
SN74LS151N	1 28
SN74LS155N	1 80
SN74LS157N	1 40
SN74LS160N	2 05
SN74LS163N	2 05
SN74LS170N	2 85
SN74LS192N	2 60
SN74LS194N	2 00
SN74LS197N	2 00
SN74LS257N	1.75
SN74LS258N	2 20
SN74LS290N	2.00
SN74LS670N	3.50
N8885A	1 13

LINEAR

CA3082	1 90
CA3089	2 75
LM301AN	35
LM301AH	35
LM307N	35
LM308N	89
LM309K	1 25
LM311H	90
LM339N	1 55
LM340K-5	1 60
LM350N	1 00
LM351N	60
LM380N	1 00
LM710N	65
LM723N	44
LM733N	89
LM741N	35
LM1303N	82
LM2111N	1 95
LM3900N	55
LM3909	70
MC1458V	59
NE540L	5 00
NE550N	65
NE553B	2 30
NE555V	43
NE556A	1 00
NE565A	1 15
NE566V	1 85
NE567V	1 45
SN75451CN	39
SN75452CN	39

CMOS

CD34001	42
CD4001	25
CD4002	25
CD4011	25
CD4012	25
CD4013	40
CD4016	50
CD4017	1 00
CD4020	1 35
CD4024	1 20
CD4027	55
CD4030	55
CD4049	62
CD4050	62
CD4071	40
CD4072	40
CD4082	45
CD4511	2 20
CD40192	3 00
74C160	2 00
74C192	2 40
74C221	2 75

INTERFACE

N8T25V	3.20
N8T26V	2 75
N8T28B	2 75
N8T97B	3 25

DISPLAY LEDS

MAN1	CA	270	2 90
MAN3	CC	125	39
MAN4	CC	187	1 95
MAN7	CA	300	1.50
MAN72	CA	300	1 50
MAN74	CC	300	1 50
DL707	CA	300	1 50
DL727	CA	500	2 55
DL747	CA	600	2 25
FND503	CC	500	1 35
FND510	CA	500	1 35
FND800	CC	800	2 75
FND807	CA	800	2 75
MV5022			69
MV5082			89
5082-7414			1 40

MOS/MEMORY RAM

2102	1 80
2102-1	1 80
2102-2	1 80
21L02	1 80
2107	18.50
2112-2	7 90

UART

AY5-1013	6 20

A to D CONVERTER

8700CN	16 00

PROM

1702A	13 00
N82S23	3 25
N82S123	4 00
N82S126	4 85

MICRO-PROCESSOR

8080	24 50
8080A	33 00

ECL 10,000 SERIES

10101	39
10123	1 10
10124	1 10
10125	1 10

MICROPROCESSOR KIT
Signetics Bipolar SK3000KT1000 A $234 00 value. Just $100 00
INCLUDES
4-3002 3-82S114
1-3001 2-8T26
1-74S182 1-8T31
6K of Memory

CRYSTALS

1 MHz	4 50
2 MHz	4 50
4 MHz	4 25
5 MHz	4 25
10 MHz	4 25
18 MHz	3 90
20 MHz	3 90
32 MHz	3 90
32768 Hz	4 00

CLOCKS

MM5311	3 60
MM5312	4 80
MM5313	3.60
MM5314	3 30
MM5315	4 00
MM5316	6.35
CT7001	5 80

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14	18	28	43
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18	27	40	61
22	35		

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7451	.14	74181	1.50
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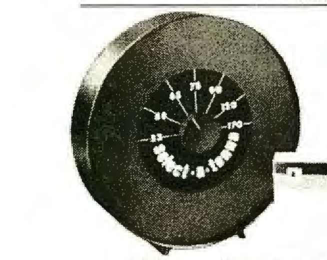

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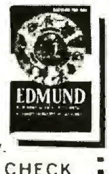

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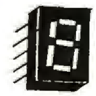

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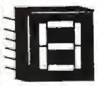

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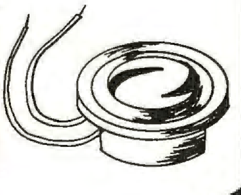

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2SA505	.70	2SB370	.65	2SC535	.75	2SC1010	.80	2SD68	.90
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2SA699A	1.75	2SB481	2.10	2SC644	.70	2SC1170	4.00	2SD313	1.10
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2N178	.90	2N1142	2.25	2N2222A	.30	2N3053	.30	2N3819	.32	2N4410	.25
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2N443	1.75	2N1543	2.70	2N2327	3.80	2N3393	.20	2N3906	.25	2N5064	.50
2N456	1.10	2N1544	.80	2N2328	4.20	2N3394	.17	2N3925	3.75	2N5130	.20
2N501A	3.00	2N1549	1.25	2N2329	4.75	2N3414	.17	2N3954	3.50	2N5133	.15
2N508A	.45	2N1551	2.50	2N2368	.25	2N3415	.18	2N3954A	3.75	2N5138	.15
2N555	.45	2N1552	3.25	2N2369	.25	2N3416	.19	2N3955	2.45	2N5198	3.75
2N652A	.85	2N1554	1.25	2N2484	.32	2N3417	.20	2N3957	1.25	2N5294	.50
2N677C	6.00	2N557	.15	2N2712	.18	2N3442	1.85	2N3958	1.20	2N5296	.50
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2N706B	.40	2N1605	.35	2N2903	3.30	2N3563	.20	2N4093	.85	2N5354	.20
2N711	.50	2N1613	.30	2N2904	.25	2N3565	.20	2N4124	.20	2N5369	.20
2N711B	.60	2N1711	.30	2N2904A	.30	2N3638	.20	2N4126	.20	2N5400	.40
2N718	.25	2N1907	4.10	2N2905	.25	2N3642	.20	2N4141	.20	2N5401	.50
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2N918	.35	2N2218	.25	2N2906A	.30	2N3646	.14	2N4220A	.45	C103D	.40
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SN7403N	16	SN7460N	.22	SN74154N*	1 25
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SN7406N	20	SN7472N	.39	SN74157N	99
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SN7408N	25	SN7474N*	32	SN74161N	99
SN7409N	25	SN7475N*	50	SN74163N*	99
SN7410N*	.18	SN7476N*	32	SN74164N	1 10
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SN7426N	29	SN7493N*	49	SN74181N	2 49
SN7427N	37	SN7494N	79	SN74182N	95
SN7429N	42	SN7495N	79	SN74184N	1 95
SN7430N	26	SN7496N	89	SN74185N	2 20
SN7432N	31	SN7497N*	4 00	SN74186N*	5 00
SN7437N	27	SN74100N*	1 00	SN74187N	6 00
SN7438N	27	SN74107N	39	SN74190N	1 19
SN7439N	25	SN74121N*	39	SN74191N	1 25
SN7440N	15	SN74122N	39	SN74192N*	89
SN7441N	89	SN74123N*	70	SN74193N*	89
SN7442N	59	SN74125N	60	SN74194N	1 25
SN7443N	75	SN74126N	60	SN74195N	75
SN7444N	75	SN74132N	1 09	SN74196N	1 25
SN7445N	75	SN74136N	95	SN74197N	75
SN7446N	81	SN74141N	1 15	SN74198N	1 75
SN7447N*	69	SN74142N*	4.00	SN74199N	1 75
SN7448N	.79	SN74143N*	4.50	SN74200N	5.59
SN7450N	26	SN74144N*	4 50	SN74279N*	90
SN74.. N	27	SN74145N	1 15	SN74251N	1 79
		SN74147N	2 35	SN74284N	6 00
		SN74148N	2 00	SN74285N	6 00

MANY OTHERS AVAILABLE ON REQUEST
20% Discount for 100 Combined 7400's

CMOS

CD4000	25			74C04N	75
CD4001	25	CD4035	1 85	74C10N	65
CD4002	25	CD4040	2 45	74C20N	65
CD4006	2 50	CD4042	1 90	74C30N	65
CD4007	25	CD4044	1 50	74C42N	2 15
CD4009	59	CD4046	2 51	74C73N	1 50
CD4010	59	CD4047	2 75	74C74	1 15
CD4011	25	CD4049	79	74C90N	3 00
CD4012	25	CD4050	79	74C95N	2 00
CD4013	47	CD4051	2 95	74C107N	1 25
CD4016	56	CD4053	2 95	74C151	2 90
CD4017	1 35	CD4060	3 25	74C154	3 00
CD4019	55	CD4066	1 75	74C157	2 15
CD4020	1 49	CD4069	45	74C160	3 25
CD4022	1 25	CD4071	45	74C161	3 25
CD4023	25	CD4072*	45	74C163	3 00
CD4024	1 10	CD4081	45	74C164	3 25
CD4025	25	CD4511	2	74C173	2 60
CD4027	69	CD4518	2	74C174	2 75
CD4028	1 65	74C00N	39	74C195	2 75
CD4029	2 90	74C02N	55	MC4044*	4 50
CD4030	65			MC14016*	56

LINEAR

LM300H	80			LM1351N	1 65
LM301H	35			LM1414N	1 75
LM301CN	35	LM377N	4 00	LM1458C	65
LM302H	75	LM380N	1 39	LM1496N	95
LM304H	1 00	LM380CN	1 05	LM1556V	1 85
LM305H	95	LM381N	1 79	LM2111N	1 95
LM307CN	35	LM382N	1 79	LM2901N	2 95
LM308H	1 00	NE501K	8 00	LM3065N	69
LM308CN	1 00	NE510A	6 00	LM3900N	55
LM309H	1 10	NE531H	3 00	LM3905N	60
LM309K	99	NE536T	6 00	LM3909*	1.25
LM310CN	1 15	NE540L	6 00	LM5556N	1 85
LM311H	90	NE550N	79	MC5558V	1 00
LM311N	90	NE553	2 50	LM7525N	90
LM318CN	1 50	NE555V*	45	LM7535N	1 25
LM319N	30	NE560B*	5 00	8038B*	4 95
LM319D	9 00	NE561B*	5 00	LM75450	49
LM320K-5	1 35	NE562B*	5.00	75451CN	39
LM320K 5 2	1 35	NE565H*	99	75452CN	39
LM320K 12	1 35	NE565N*	1 25	75453CN	39
LM320K 15	1 35	NE566CN*	1 95	75454CN	39
LM320T-5*	1 75	NE567H*	1 25	75491CN	79
LM320T-8*	1 75	NE567V*	1 50	75492CN	89
LM320T-12*	1 7	LM703CN	45	75494CN	89
LM320T-18*	1 75	LM709H	29	**RCA LINEAR**	
LM323K-5*	9.95	LM709N	29	CA3013	1 70
LM324N	1 80	LM710N	79	CA3023	2 15
LM339N	1 70	LM711N	39	CA3035	2 25
LM340K 5	1 95	LM723N	55	CA3039	1 35
LM340K-12	1 95	LM723H	55	CA3046	1 15
LM340K-15	1 95	LM733N	1 00	CA3059	2 46
LM340K-24	1 95	LM739N	1 29	CA3060	2 80
LM340T-5	1 75	LM741CH	35	CA3080	85
LM340T 6	1 75	LM741CN	35	CA308*	1.75
LM340T-8*	1 75	LM741 14N	39	CA3082	2.00
LM340T-18*	1 75	LM747H	79	CA3083	1 60
LM340T 12	1 75	LM747N	79	CA3086	59
LM340T-15	1 75	LM748H	39	CA3089	3 25
LM340T 24	1 75	LM748N	39	CA3091	8 25
LM350N	1 00	LM1303N	90	CA3123	1 85
LM351CN	65	LM1304N	1 19	CA3130*	1.49
LM370N	1 15	LM1305N	1 40	CA3600	1 75
LM370H	1 15	LM1307N	85	RC4194	5 95
LM373N	3 25	LM1310N	2 95	RC4195	3 25

KITS EXAR ICS

XR-2206KA **SPECIAL $17.95**
Includes monolithic function generator IC, PC board, and assembly instruction manual

XR-2206KB **SPECIAL $27.95**
Same as XR 2206KA above and includes external components for PC board

TIMERS		**STEREO DECODERS**	
XR-555CP	$ 69	XR-1310P	$3 20
XR-320P	1 35	XR-1310EP	3 20
XR-556CP	1 85	XR1800P	3 20
XR-2556CP	3 20		
XR-2240CP	3.25	**WAVEFORM GENERATORS**	
		XR-205	8.40
PHASE LOCKED LOOPS		XR-2206CP	4 49
		XR-2207CP	3 85
XR-210	5 20		
XR-215	6 60	**MISCELLANEOUS**	
XR-567CP	1 95	XR-2211CP	6 70
XR-2567CP	2 99	XR-2261	3 79
		XR4136*	2 00

DATA HANDBOOKS

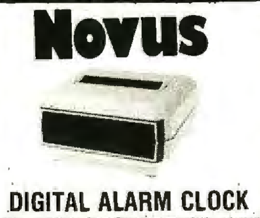
7400	Pin-out & Description of 5400/7400 ICS	$2.95
CMOS	Pin-out & Description of 4000 Series ICS	$2.95
LINEAR	Pin-out & Functional Description	$2.95

ALL THREE HANDBOOKS $6.95

CONSUMER ELECTRONICS

DIGITAL WATCH
This watch is manufactured by National Semiconductor. It provides 5 functions, hours, minutes, seconds, date, A M indicator dot. Accuracy is assured to 5 seconds per month by precision quartz crystal. If something should go wrong with the watch, repair is assured within 48 hours after it is received. Complete with steel black leather band.

ES4-YS
3 MICRON GOLD PLATE BEZEL
$29.95
NOT A KIT



DIGITAL ALARM CLOCK
This 4 digit Novus Alarm Clock is a very reliable and smartly styled unit. It provides such features as an alarm settable to any minute of the day, a 7 minutes snooze alarm, a power failure indicator, and even an A.M., P.M. indicator.

NOT A KIT **$19.95**

OPTO ELECTRONICS

XCITON
LITRONIX
MONSANTO

DISCRETE LEDS

R - RED
G - GREEN
Y - YELLOW
O - ORANGE

125" dia.

XC209R	5/$1
XC209G	4/$1
XC209Y	4/$1
XC2090	4/$1

.185" dia.

XC526R	5/$1
XC526G	4/$1
XC526Y	4/$1
XC5260	4/$1

.190" dia.

XC111R	5/$1
XC111G	4/$1
XC111Y	4/$1
XC1110	4/$1

.200" dia.

XC22R	5/$1
XC22G	4/$1
XC22Y	4/$1
XC220	4/$1

.200" dia.

XC556R	5/$1
XC556G	4/$1
XC556Y	4/$1
XC5560	4/$1

.085" dia.

MV50
085" dia. Micro red led
6/$1

DISPLAY LEDS

FND503 FND70 DL707 MAN 2 MAN 3 MAN 4 MAN 7 DL747 DL33B

TYPE	POLARITY	HT		TYPE	POLARITY	HT	
MAN 1	COMMON ANODE	270	$3.25	MAN 74	COMMON CATHODE	300	$1 50
MAN 2	5 x 7 DOT MATRIX	300	4.95	DL707	COMMON ANODE	300	$1 50
MAN 3	COMMON CATHODE	125	39	DL747	COMMON ANODE	.600	2.25
MAN 4	COMMON CATHODE	.187	1.95	DL750	COMMON CATHODE	.600	2.49
MAN 7	COMMON ANODE	300	1 50	DL33B	COMMON CATHODE	.110	1.25
MAN 7G	COMMON ANODE-GREEN	300	1 95	FND70	COMMON CATHODE	250	50
MAN 7Y	COMMON ANODE-YELLOW	300	1 95	FND503	COMMON CATHODE	500	1 75
MAN 72	COMMON ANODE	300	1 50	FND507	COMMON ANODE	500	1.75

IC SOLDERTAIL — LOW PROFILE (TIN) SOCKETS

	1-24	25-49	50 100		1-24	25-49	50-100
8 pin	$ 17	16	15	24 pin	$.38	37	.36
14 pin	20	19	18	28 pin	.45	.44	.43
16 pin	22	21	20	36 pin	.60	59	58
18 pin	29	28	27	40 pin	63	.62	61
22 pin	37	36	35				

SOLDERTAIL STANDARD (TIN)

14 pin	$ 27	25	24	28 pin	$ 99	.90	81
16 pin	.30	27	25	36 pin	1 39	1.26	1 15
18 pin	35	32	30	40 pin	1 59	1.45	1 30
24 pin	49	45	42				

SOLDERTAIL STANDARO (GOLD)

8 pin	$ 30	27	24	24 pin	$ 70	63	.57
14 pin	35	.32	29	28 pin	1 10	1.00	90
16 pin	38	35	.32	36 pin	1 75	1.40	1.26
18 pin	52	47	43	40 pin	1.75	1.59	1.45

WIRE WRAP SOCKETS (GOLD) LEVEL #3

10 pin	$ 45	41	37	24 pin	$1 05	.95	85
14 pin	39	38	37	28 pin	1.40	1.25	1.10
16 pin	43	42	41	36 pin	1 59	1.45	1 30
18 pin	75	68	62	40 pin	1 75	1.55	1.40

50 PCS. RESISTOR ASSORTMENTS $1.25 PER ASST.

		10 OHM	12 OHM	15 OHM	18 OHM	22 OHM	
ASST. 1	5 ea.	27 OHM	33 OHM	39 OHM	47 OHM	56 OHM	1/4 WATT 5% = 50 PCS.
		68 OHM	82 OHM	100 OHM	120 OHM	150 OHM	
ASST. 2	5 ea.	180 OHM	220 OHM	270 OHM	330 OHM	390 OHM	1/4 WATT 5% = 50 PCS.
		470 OHM	560 OHM	680 OHM	820 OHM	1K	
ASST. 3	5 ea.	1.2K	1 5K	1 8K	2 2K	2 7K	1/4 WATT 5% = 50 PCS.
		3 3K	3 9K	4 7K	5 6K	6 8K	
ASST. 4	5 ea.	8 2K	10K	12K	15K	18K	1/4 WATT 5% = 50 PCS.
		22K	27K	33K	39K	47K	
ASST. 5	5 ea.	56K	68K	82K	100K	120K	1/4 WATT 5% = 50 PCS.
		150K	180K	220K	270K	330K	
ASST 6	5 ea.	390K	470K	560K	680K	820K	1/4 WATT 5% = 50 PCS.
		1M	1 2M	1 5M	1.8M	2.2M	
ASST. 7	5 ea.	2 7M	3 3M	3 9M	4 7M	5.6M	1/4 WATT 5% = 50PCS.

ALL OTHER RESISTORS FROM 2 2 OHMS 5 6M AVAILABLE IN MULTIPLES OF 5 ea
5-25 PCS 05 ea 30-95 PCS 04 ea 100-495 PCS 03 ea 500-995: .0275 ea

14 PCS. POTENTIOMETER ASSORTMENTS

ASST. A 2 ea. 10 OHM-20 OHM-50 OHM-100 OHM-200 OHM-250 OHM-500 OHM
ASST B 2 ea 1K, 2K, 5K, 10K, 20K, 70K 50K
ASST. C 2 ea. 50K, 100K, 200K, 250K, 500K, 1M, 2M

$9.95 Per Asst.

Each assortment contains 14 pcs of 10 turn pots. All pots are available in single unit quantities. $.99 ea.

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Satisfaction Guaranteed. $5.00 Min. Order. U.S. Funds.
California Residents — Add 6% Sales Tax — Data Sheets 25c each
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74LS00 TTL

74LS00	39	74LS55	.39	74LS151	1 55
74LS02	39	74LS73	65	74LS153	1 89
74LS03	39	74LS74	65	74LS157	1 55
74LS04	45	74LS75	79	74LS162	2 25
74LS05	45	74LS76	65	74LS163	2 25
74LS08	39	74LS83	2 19	74LS164	2 25
74LS10	39	74LS86	65	74LS181	3.69
74LS13	79	74LS90	1 25	74LS190	2 85
74LS14	2 19	74LS92	1 25	74LS191	2 85
74LS20	39	74LS93	1 25	74LS192	2 85
74LS26	49	74LS95	2 19	74LS193	2.85
74LS27	45	74LS96	1.89	74LS194	2 25
74LS28	49	74LS107	65	74LS195	2.25
74LS30	39	74LS112	.65	74LS257	1.89
74LS32	45	74LS132	1.55	74LS260	.55
74LS40	49	74LS136	65	74LS279	.79
74LS51	39	74LS138	1.89	74LS670	5.95

THIS MONTH ONLY!!! DL728
The DL728 is a dual 0.5" common cathode red display. It is ideal for use with clock chips, as segments are already multiplexed. **$1.95**

MINATURE TOGGLE

DPDT				JMT	1	2-9	10-29	30-99
	ON	OFF	ON	221	3 05	2 65	1 97	1 78
	ON	NONE	ON	223	2 65	2 25	1 68	1 51
	ON	OFF	ON	121	2 35	1 95	1 43	1 30
	ON	NONE	ON	123	2 05	1 65	1 21	1 10

PUSH BUTTON

SPDT – SERIES PB, PB1

	Model Number	1 Each	2-9	10-29	30-99
Maintained Action Switch: Push To Make Contact And Push Again To Reserve Action	PB-123	$2.35	$1.95	$1.47	$1.30
Momentary Action Switch: Normally Open or Normally Closed (For N C circuit use terminals 2 & 1, for N O, 2 & 3 for N C and N O 1 2 & 3	PB-126	$2.35	$1.95	$1.47	$1.30

Quanity net prices
5 AMP RATINGS

THUMBWHEEL SWITCHES

THUMBWHEEL SWITCH ONLY
SF – Front Mount SR – Rear Mount

Part No	Description	Price
SF 12	Single Pole 10 Position	$2 50
SR 12	Decimal	3 00
SF 21	10 Position BCD only	2 50
SR 21	" "	3 00

Ordering: Order desired switch or switches and add necessary accessories for your particular application

SERIES SF Front Mount Assembly — SERIES SR Rear Mount Assembly

ACCESSORIES

Part No	Description	Price
SF EP	End Plate (Pair)	$ 50
SF DP	Divider Plate (each)	40
SF BB	Blank Body (each)	40
SF HB	Half Body (each)	40

ACCESSORIES

Part No.	Description	Price
SR EP	End Plates (pair)	$ 50
SR DP	Divider Plate (each)	40
SR BB	Blank Body (each)	40
SR HB	Half Body (each)	40

8 POSITION ROTARY SWITCH **2 FOR $1.00**
These switches are a 7 position, one position open, rotary switch enclosed in a TO-5 can. They have a standard 8 pin configuration and will mount perfectly on printed circuit board

ZENERS—DIODES—RECTIFIERS

TYPE	VOLTS	W	PRICE	TYPE	VOLTS	W	PRICE
1N746	3 3	400m	4/1.00	1N4005*	600 PIV	1 AMP	10/1.00
1N751A	5 1	400m	4/1.00	1N4006*	800 PIV	1 AMP	10/1.00
1N752	5 6	400m	4/1 00	1N4007*	1000 PIV	1 AMP	10/1.00
1N753	6 2	400m	4/1.00	1N3600	50	200m	6/1.00
1N754	6 8	400m	4/1 00	1N4148	75	10m	15/1.00
1N9658	15	400m	4/1.00	1N4154	35	10m	12/1.00
1N5232	5 6	500m	28	1N4734	5.6	1w	28
1N5234	6 2	500m	28	1N4735	6.2	1w	28
1N5235	6 8	500m	28	1N4736	6.8	1w	28
1N5236	7 5	500m	28	1N4738	8.2	1w	28
1N456	25	40m	6/1 00	1N4742	12	1w	28
1N458	150	7m	6/1.00	1N4744	15	1w	28
IN485A	180	10m	5/1 00	1N1183	50 PIV	35 AMP	1 60
1N4001	50 PIV	1 AMP	12/1 00	1N1184	100 PIV	35 AMP	1.70
1N4002	100 PIV	1 AMP	12/1 00	IN1186	200 PIV	35 AMP	1.80
1N4003	200 PIV	1 AMP	12/1 00	1N1188	400 PIV	35 AMP	3.00
1N4004	400 PIV	1 AMP	12/1 00				

TRANSISTORS

MPS A05	5/$1 00			PN4249	4/$1 00
MPS A06	5/$1 00	PN3567	3/$1 00	PN4250	4/$1 00
2N2219A	3/$1 00	PN3568	4/$1 00*	2N4400	4/$1 00
2N2221	4/$1 00	PN3569	4/$1 00	2N4401	4/$1 00
2N2222A	5/$1.00	2N3704	5/$1 00	2N4402	4/$1 00
2N2369	5/$1.00	2N3705	5/$1.00	2N4403	4/$1 00
2N2369A	4/$1 00	2N3706	5/$1.00	2N4409	5/$1 00
FN2415	5/$1 00	2N3707	5/$1 00	2N5086	4/$1 00
2N2484	4/$1 00	2N3711	5/$1.00	2N5087	4/$1 00
2N2906A	4/$1 00	2N3724	$ 65	2N5088	4/$1 00
2N2907A	5/$1 00	2N3725	$1 00	2N5089	4/$1 00
2N2925	5/$1 00	2N3903	5/$1 00	2N5129	5/$1 00
2N3053	2/$1 00	2N3904	4/$1 00	2N5138	5/$1.00
2N3055	$ 89	2N3905	4/$1.00	2N5139	5/$1 00
MJE3055	$1 00	2N3906	4/$1 00	2N5209	5/$1 00
MJE2955	$1 25	2N4013	3/$1 00	2N5951	5/$1 00
2N3392	5/$1 00	2N4014	3/$1 00	C106B15CR	2/$1 00
2N3398	5/$1 00			2N5432	$2 00

CAPACITOR CORNER

50 VOLT CERAMIC DISC CAPACITORS

	1-9	10-49	50-100		1-9	10-49	50-100
	05	.04	03	001µF	.05	.04	.035
	05	.04	03	0047µF	05	.04	.035
	.05	.04	03	.01µF	.05	.04	.035
100 pf	05	.04	.03	.022µF	.06	.05	.04
220 pf	05	.04	.03	.047µF	.06	.05	.04
470 pf	05	.04	035	.1µF	.12	.09	.075
100 VOLT MYLAR FILM CAPACITORS							
001mf	12	10	.07	.022mf	.13	.11	.08
.0022	.12	10	.07	047mf	.21	.17	.13
.0047mf	.12	10	.07	.1mf	.27	.23	.17
01mf	12	10	.07	22mf	.33	.27	.22
+ 20% DIPPED TANTALUMS (SOLID) CAPACITORS							
1 35V	.28	.23	.17	1.5 35V	.30	.26	.21
.15 35V	.28	.23	.17	2.2 25V	.31	.27	.22
.22 35V	.28	.23	.17	3 3 25V	.31	.27	.22
33 35V	.28	.23	.17	4 7 25V	.32	.28	.23
.47 35V	.28	.23	.17	6.8 25V	.36	.31	.25
68 35V	.28	.23	.17	10 25V	.40	.35	.29
1.0 35V	.28	.23	.17	15 25V	.63	.50	.40
MINIATURE ALUMINUM ELECTROLYTIC CAPACITORS							
Axial Lead				**Radial Lead**			
47 50V	.15	.13	.10	.47 25V	.15	.13	.10
1.0 50V	16	.14	.11	47 50V	.16	14	.11
3.3 50V	15	13	.10	1.0 16V	.15	.13	.10
4 7 25V	16	14	12	1.0 25V	.16	.14	11
10 25V	15	13	10	1.0 50V	.16	.14	.11
10 50V	16	14	12	4.7 16V	.15	.13	10
22 25V	17	15	12	4.7 25V	.15	.13	.10
22 50V	24	20	.18	4.7 50V	.16	14	11
47 25V	19	17	.15	10 16V	.14	.12	.09
47 50V	25	21	.19	10 25V	.15	.13	10
100 25V	24	.20	18	10 50V	.16	.14	12
100 50V	35	30	28	47 50V	.24	21	19
220 25V	32	28	25	100 16V	.19	.15	.14
220 50V	45	41	.38	100 25V	.24	.20	.18
470 25V	33	29	.27	100 50V	.35	.30	.28
1000 16V	55	50	45	220 16V	.23	.17	.16
2200 16V	70	62	55	470 25V	.31	.28	.26

CRYSTALS

THESE FREQUENCIES ONLY

Part #	Frequency	Case/Style	Price
CY1A	1.000 MHz	HC33/U	$4.95
CY2A	2.000 MHz	HC33/U	$4.95
CY3A	4.000 MHz	HC18/U	$4.95
CY7A	5.000 MHz	HC18/U	$4.95
CY12A	10.000 MHz	HC18/U	$4.95
CY14A	14.31818 MHz	HC18U	$4.95
CY19A	18.000 MHz	HC18/U	$4.95
CY22A	20.000 MHz	HC18/U	$4.95
CY30B	32.000 MHz	HC18/U	$4.95

CLOCK CHIPS — CALCULATOR CHIPS

MM5309	6 Digit, BCD Outputs, Reset PIN.	$5.95
MM5311	6 Digit, BCD Outputs, 12 or 24 Hour	4.95
MM5312	4 Digit, BCD Outputs, 1 PPS Output	4.95
MM5313	6 Digit, BCD Outputs, 1PPS Output	4.95
MM5314	6 Digit, 12 or 24 Hour, 50 or 60 Hz	4.95
MM5316	4 Digit, Alarm, 1PPS Output	6.95
MM5318	Video Clock Chip, For Use With MM5841	9.95
CT7001	6 Digit, Calander, Alarm, 12 or 24 Hour	6.95

CALCULATOR CHIPS

MM5725	6 Digit, Four Function, Less Decimal	$2.95
MM5738	8 Digit, 5 Function, +, =, ×, −, %	2.95
MM5739	8 Digit, 4 Function, Floating Decimal	2.95
CT5001	12 Digit, 4 Function	3.95
CT5005	12 Digit, 4 Function with Memory	5.95
CT5030	12 Digit, 4 Function and %	7.95

MISC. MOS

MM5320	TV Camera Sync. Generator	$19.95
MM5330	4½ Digit DVM Chip	9.95
MM5369	60 Hz Timebase Circuit From 3.58 MHz	5.00
MM5841	Video Generator For MM5318	18.00
MC1408-L7	7 Bit Digital to Analog Converter	9.95
MK5007	4 Decade Counter with Latches	10.95
LD110/LD111	3½ Digit DVM Chip Set	25.00
95H90	100 MHz ÷ 10 Counter For Prescalers	13.95

FILAMENT TRANSFORMERS

FILAMENT single secondary 50 60 Hz

Type No	Secondary Volts	Secondary Amps	Primary Volts	Test Voltage	Connections	Price
F-7X	5 CT	3	115	1500	Leads	5.10
F-13X	6.3	1	115	1500	Leads	3.80
F-14X	6.3 CT	[illegible]	115	Pri 1500C Sec 2500	Leads	4.15
F-16X	6.3 CT	3	115	Pri 1500 Sec 2500	Leads	5.35
F-25X	12.6 CT	1.5	115	1500	Leads	5.25
F-40X	26.8 CT	1	115	1500	Leads	7.00
F-45X	24.8 CT	1	115	1500	Leads	7.50
F-54X	35.0 CT	1.5	115	1500	Leads	8.50

Add 50¢ Postage

VECTOR WIRING PENCIL

Vector Wiring Pencil P173 consists of a hand held featherweight (under one ounce) tool which is used to guide and wrap insulated wire, fed off a self-contained replaceable bobbin, onto component leads or terminals installed on pre-punched "P" Pattern Vectorbord®. Connections between the wrapped wire and component leads, pads or terminals are made by soldering. Complete with 250 FT of red wire. **$9.50**

REPLACEMENT WIRE — BOBBINS FOR WIRING PENCIL

W36-3-A-Pkg. 3	250 ft. 36 AWG GREEN	$2.40
W36-3-B-Pkg. 3	250 ft. 36 AWG RED	$2.40
W36-3-C-Pkg. 3	250 ft. 36 AWG CLEAR	$2.40
W36-3-D-Pkg. 3	250 ft. 36 AWG BLUE	$2.40

1/16 VECTOR BOARD

0.1" Hole Spacing

	Part No	P-Pattern L	W	Price 1-19	20-49
PHENOLIC	64P44 062XXXP	4 50	6 50	1 72	1 54
	169P44 062XXXP	4 50	17.00	3 69	3 32
EPOXY GLASS	64P44 062	4 50	6 50	2 07	1 86
	84P44 062	4 50	8 50	2 56	2 31
	169P44 062	4 50	17 00	5 04	4 53
	169P84 062	8 50	17 00	9 23	8 28
EPOXY GLASS COPPER CLAD	169P44 062C1	4 50	17 00	6.80	6 12

VECTOR TERMINALS

Series	Part No. Finish Gold	Tinned	Post Size	25 pcs Gold	25 pcs Tin	50 pcs Gold	50 pcs Tin
T44	T44-1	T44	025 sq	1 50 lot	1 00 lot	2 75 lot	1 75 lot
T46	T46-1	T46	028 sq	1.75 lot	1 25 lot	3 00 lot	2 25 lot
T49	T49A	T49	025 sq	1 75 lot	1 25 lot	3 10 lot	2.25 lot

T42-1 PKG 100 Terminals $3.50 C $13.00M

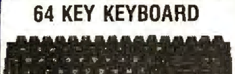
DIP SWITCH

These switches feature seven SPST slide switches in a molded dip. They are ideally suited for microprocessor applications. **$1.95**

SCR AND FW BRIDGE RECTIFIERS

C36D	15A @ 400V	SCR	$1.95
C38M	35A @ 200V	SCR	1.95
2N2328	1.6A @ 200V	SCR	.50
MDA 980-1	25A @ 50V	FW BRIDGE REC.	1.95
MDA 980-3	25A@ 200V	FW BRIDGE REC.	1.95

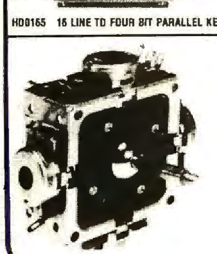
64 KEY KEYBOARD



This keyboard features 64 unencoded SPST keys, unattached to any kind of P.C.B. A very solid molded plastic 13" x 4" base suits most applications. **$19.95**

HD0165 16 LINE TO FOUR BIT PARALLEL KEYBOARD ENCODER $7.95

JOYSTICK



These joysticks feature four 100K potentiometers, that vary resistance proportional to the angle of the stick. Sturdy metal construction with plastics components only at the movable joint. Perfect for electronic games and instrumentation.

$9.95 ea.

MICROPROCESSOR COMPONENTS

8080 SUPPORT DEVICES

8080A $37.95				8080 $24.95
	8212	8 BIT INPUT/OUTPUT PORT FOR 8080	$ 5.95	
	8224	CLOCK GENERATOR AND DRIVER FOR 8080	12.95	
	8228	SYSTEM CONTROLLER AND BUS DRIVER FOR 8080	12.95	

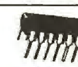
	CPU'S				RAM'S	
8008	8 BIT CPU	$19.95	2601	256 x 1	FAST	5.00
8080	Super 8008	24.95	1101	256 x 1	Static	$ 2.25
8080A	Super 8008	37.95	1103	102 x 1	Dynamic	2.95
	SR'S		2101	256 x 1	Static	6.95
2504	1024 Dynamic	$ 9.00	2102	1024 x 1	Static	1.95
2518	Hex 32 BIT	7.00	2107	4096 x 1	Dynamic	19.95
2519	Hex 40 BIT	4.00	2111	256 x 4	Static	7.95
2524	512 Dynamic	2.95	7010	1024 x 1	MNOS	29.95
2525	1024 Dynamic	6.00	7489	16 x 4	Static	2.49
2527	Dual 256 BIT	3.95	8101	256 x 4	Static	7.95
2529	Dual 512 BIT	4.00	8111	256 x 4	Static	7.95
2532	Quad 80 BIT	3.95	8599	16 x 4	Static	3.49
2533	1024 Static	7.95	91L02	1024 x 1	Static	2.49
3341	Fifo	6.95	74200	256 x 1	Static	6.95
74LS670	15 x 4 Reg	3.95	93410	256 x 1	Static	1.75
	UART'S				PROMS	
AY-5-1013	30K Baud	$ 6.95	1702A	2048	Famos	$15.95
	ROM'S		5203	2048	Famos	14.95
2513	Char. Gen	$11.00	82S23	32 x 8	Open C	5.00
2516	Char. Gen.	13.00	82S123	32 x 8	Tristate	5.00
74S387	1024-Bit Programmable	1.95	74S287	1024	Static	7.95

2K RAM SPECIAL

MM5262 Fully decoded 2Kx1 dynamic RAM. All inputs except clocks are TTL compatible. Provides a 635 ns minimum access time, and requires, a +5, +8.5, and −15V power supply. Low power provides non volatile memory using battery back up.

$0.99 ea. (0.05 cents per bit)

Special Requested Items



RC4194	Dual Track V Reg	$ 5.95	N8T97	$ 2.00	MK5007	$10.95	MC4044	$ 4.50
RC4195	±15V Track Reg	3.25	4024P	2.25	8263	5.95	LM3909	1.25
F9368	Decoder	3.95	DM8130	3.25	8267	2.75	MM5320	19.95
LD110/111	DVM Chip Set	25.00	9322	1.30	8288	1.15	4072AE	.45
CA3130	Super CMOS Op Amp	1.49	MC14016	.56	8826	3.00	7422	1.50
MC1408L7	D/A	9.95	2525	6.00	8880	.80	7497	4.00
F3341	FIFO	6.95	2527	3.95	4511AE	2.50	74186	5.00
MM5841	Character Gen	18.00	CD4516	2.50	XR4136	2.00	74279	.90
AY5-9100	Push Button Dialer	17.50	MM5309	5.95	4566AE	3.00	82S90	4.00
	WE'LL BE HAPPY TO QUOTE ON YOUR SPECIAL PARTS —						MCT-2E	2.95

Continental Specialties

PROTO POWER!

POWER FOR THE PROFESSIONAL

$75 Proto Board 203

Made in USA Patents Pending

Breadboard Prototyping with 5 Volt, 1 AMP Regulated Power Supply Included!

A total ready to use power breadboard prototype device with a built-in regulated short-proof power supply. Just plug in and start building! 2 extra floating 5-way binding posts for external signals. Self-contained with power switch indicator lamp and power fuse. 24-14 pin DIP capacity. Attractive two-tone quality case. All metal construction. 9¾" L x 6½" W x 2¾" H. 5 lbs. Order today!

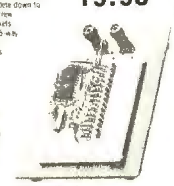
For the economy-minded experimenter . . .

NEW

Proto Board 100

19.95

Here's a low cost, big 10 IC capacity breadboard kit with all the quality of QT Sockets and the best of the Proto Board series . . . complete down to the last nut, bolt and screw. Includes 2 QT 35S Sockets, 1 QT-35B Bus Strip, 2 5-way binding posts, 4 rubber feet, screws, nuts, bolts and easy assembly instructions.



Proto Board 104
Huge 3,060 solderless tie points. (4) 5-way binding posts. 32 14 pin DIP capacity. 9½" long x 8" wide **79.95**

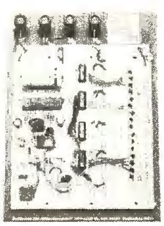
COMPLETE KIT

THE MINI-BREADBOARD BUDGET KIT

Proto Board 101
Compact, inexpensive 10 14 pin DIP capacity 5.8" long x 4.5" wide **29.95**

Proto Board 102 Compact 17 14 pin DIP capacity 7" x 4½" **39.95**

Proto Board 103
2,250 solderless tie points. (4) 5 way binding posts. 24 14 pin DIP capacity. 9" x 6" **59.95**



DESIGN MATE 1

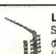
CIRCUIT DESIGNER
You asked for it. HERE IT IS! CSC's basic circuit designer to help you build and test ANY electronic circuit. Solid #22 AWG wire interconnects any discreet component without solder. Resistors, Transistors, Linear/Digital ICs in TO-5/DIP packages (from 8-40 pins). And more . . . components fit directly into sockets, and Bus strips instantly and easily. Plus, DESIGN MATE ONE's (DM-1) variable regulated power supply gives 5-15VDC up to 600ma (9 watts). Now that's design flexibility for you!
You can even monitor the DM-1's internal power supply or external circuits thanks to the built-in 0-15V voltmeter. If you're into electronics, DM-1 is a must for your laboratory. It comes to you completely wired, tested and ready to use for only **$49.95**

PROTO BOARD 6
The PB-6 lets the user test and build circuits without soldering or patch cords. . . all interconnections between components are made with common #22 AWG hook-up wire. This quality breadboarding kit includes 630 component tie points at less than 2.5 cents each. It measures 6" long by 4" wide. Designed specially to Breadboard Microprocessor Circuits. **$15.95**

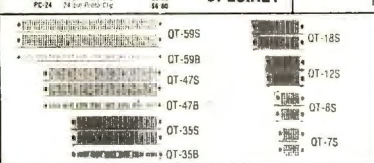
Now trace signals or troubleshoot fast. Inject signals or wire unused circuits into existing boards. Scope probes, test leads lock onto Dynagrip insert. Plastic construction . . . no springs or pivots. Thousands of operations. Narrow throat for high density PC boards.

PC-14	14 pin Proto Clip	$3.60 ea.
PC-16	16 pin Proto Clip	$3.80
PC-24	24 pin Proto Clip	$6.80

SPECIAL!



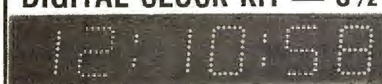
LOGIC MONITOR
Simultaneously displays static and dynamic logic states of DTL, TTL, HTL or CMOS DIP ICs.
Pocket size. **$84.95.**



QT Proto Strips

QT type	#holes	price
QT-59S	590	12 50
QT-59B	bus strip	2 50
QT-47S	470	10.00
QT-47B	bus strip	2 25
QT-35S	350	8 50
QT-35B	bus strip	2 00
QT-18S	180	4 75
QT-12S	120	3 75
QT-8S	80	3 25
QT-7S	70	3.00

DIGITAL CLOCK KIT — 3½ INCH DIGITS



This clock features big 3½" high digits for viewing in offices, auditoriums, etc. Each digit is formed by 31 bright 0.2" LED's. The clock operates from 117 VAC, has either 12 or 24 hr. operation. The 6 digit version is 27" x 3½" x 1½", and the 4 digit is 18" x 3½" x 1½". Kits come complete with all components, case and transformer.

4 DIGIT KIT $49.95	4 DIGIT ASSEMBLED $59.95
6 DIGIT KIT $69.95	6 DIGIT ASSEMBLED $79.95

Specify 12 Or 24 Hr. When Ordering

Satisfaction Guaranteed. $5.00 Min. Order. U.S. Funds.
California Residents — Add 6% Sales Tax — Data Sheets 25c each
Send a 13c Stamp (postage) for a FREE 1976 Catalog

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AUTOTEL ™

WARNING LIGHTS ARE NOT ENOUGH

AN AUDIBLE ALARM INDICATING POTENTIAL ENGINE DAMAGE

AUTOTEL is an effecient (15 ma current standby) device by which every owner of an automobile, truck or vehicle equipped with indicator lights for temperature and oil pressure can be assured of a reliable warning **before** an impending failure.

AUTOTEL, by means of an audible signal 70 db pulsing) immediately forewarns the vehicle operator of a malfunction or failure, allowing time to correct and prevent major engine failures. It is programmed so there is no sound during normal operating conditions.

AUTOTEL features CMOS circuitry, packaged in a 2½" sq. x ⅞" case. The kit comes complete with all components, hardware and case to hook directly into your car's warning light system.

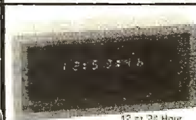
$14.95 Assembled $9.95 Per Kit

IMC 3½ DIGIT DVM KIT

This 0-2 VDC .05 per cent digital voltmeter features the Motorola 3½ digit DVM chip set. It has a .4" LED display and operates from a single +5V power supply. The unit is provided complete with an injection molded black plastic case complete with Bezel. An optional power supply is available which fits into the same case as the 0-2V DVM allowing 117 VAC operation.

A. 0-2V DVM with Case	$49.95
B. 5V Power Supply	$14.95

JE700 CLOCK



12 or 24 Hour

115 VAC

The JE700 is a low cost digital clock, but is a very high quality unit. The unit features a simulated walnut case with dimensions of 6" x 2½" x 1". It utilizes a MAN72 high brightness readout, and the MM5314 clock chip.

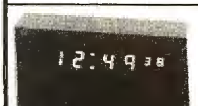
$17.95

Liquid Crystal Temperature Display

Six Digit Light Emitting Diode Display

DL 33 Display

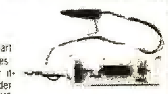
This clock makes an attractive addition to any desk. It has an extruded, black anodized aluminum case. It displays hours, minutes, and seconds with .11 inch displays, and comes complete with a liquid crystal thermometer. It operates off 115 VAC at 50 or 60 Hz. **$24.95**



This large digit clock (.6" hours & minutes, .3" seconds) features the MM5314 clock chip. It operates from 117 VAC, and will operate in either a 12 or 24 hour mode. The clock is complete with a walnut grain case, and has fast set, slow set, and hold time set features.

KIT - ALL COMPONENTS & CASE $34.95
WIRED & ASSEMBLED $39.95

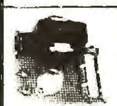
JE803 PROBE



The Logic Probe is a unit which is for the most part indespensible in trouble shooting logic families TTL, DTL, RTL, CMOS. It derives the power it needs to operate directly off of the circuit under test, drawing a scant 10 mA max. It uses a MAN3 readout to indicate any of the following states by these symbols (H) - 1 (LOW) - o (PULSE) - P. The Probe can detect high frequency pulses to 45 MHz. It can't be used at MOS levels or circuit damage will result.

$9.95 Per Kit
printed circuit board

T²L 5V 1A Supply



This is a standard TTL power supply using the well known LM309K regulator IC to provide a solid 1 AMP of current at 5 volts. We try to make things easy for you by providing everything you need in one package, including the hardware for only **$9.95 Per Kit**

NIBBLING TOOL

This Nibbling Tool is perfect for cutting, trimming or notching sheet metal up to 18 guage. It operates like a punch and die and also works well on aluminum or plastic up to 1/16" thick. We feel that this tool can be a real time-saver for our customers when working on chassis, printed circuit boards and prototype model parts.

Nibbling Tool	$6.95
Replacement Punch	$3.75 Each

DIAGONAL CUTTER

½" Semi-Flush Cut Fine Diagonal

4 in. long. Most popular cutter on assembly line—cuts at extreme tip. Semi-flush cut. For fine wire work only. No. 20 soft copper wire and smaller. Width across joint 11/32", thru pivot 7/32", tip length 1/2".

Light Blue Handle A97MS $8.50 ea.

THIS MONTH ONLY!!!

C & K Rocker Switch SPDT	2/$1.00
6PDT Push Button Switch	2/$1.00
MAN 7G Common Anode-Green .3" DISPLAY LED	$1.25
6' Black 3 Conductor Power Supply Cords	.99
LM309KC	.99
2N2222 NPN to 18 Package	8/$1.00
JE100 1¼" x 1½" PC Mount XFMER. Primary: 120 VAC @ 50 Hz-60 Hz. Secondary: 10 VAC @ 50 MA and 50 VAC @ 30 MA	.79

Miniature Aluminum Electrolytic Axial Caps

47 μF/25V	8/$1.00	470 μF/16V	5/$1.00
100 μF/25V	7/$1.00	470 μF/50V	2/$1.00
220 μF/16V	7/$1.00	10,000 μF/10V	2/$1.50

CIRCLE NO. 42 ON FREE INFORMATION CARD

IMSAI & ALTAIR OWNERS!

IMSAI 8080 Computer

All Boards Completely Plug-Compatible With Altair 8800

Basic computer includes front panel control board, LED's and switches, 28 amp power supply, expander board and cabinet . . . $599 Kit, $931 Assembled.

Interchangeable MPU, Memory and I/O Boards. Full IMSAI 8080/Altair 8800 Compatibility. No Hardware Modifications Required. Just Plug In!

Part #	Description	Kit	Assembled
MPU-A	8080 microprocessor board	$190	$350
PROM 4-4	4K bytes EPROM board	399	579
EXT	Extender board	39	49
PIC-8	Priority interrupt/interval clock board	125	238
PIO 4-1	One-port parallel I/O board	93	140
PIO 4-4	Four-port parallel I/O board	156	299
SIO 2-1	One-port serial I/O board	125	235
SIO 2-2	Two-port serial I/O board	156	299
UCRI-1	Cassette recorder I/O interface board	59	99

NEW UNIQUE 4K RAM BOARD

4K bytes of static RAM, software memory protect, circuits for battery backup, LED's status indicators . . .$139 Kit, $179 Assembled.

COMPLETE DOCUMENTATION

Introduction to Microcomputers, 460 pp	$10
INTEL 8080 Microcomputer Systems User's Manual, 157 pp	7
The T.I. TTL Handbook, 640 pp	10
Pinout Handbook, 54/7400 Series	5
IMSAI 8080 User's Manual	50
BASIC-PLUS Language Manual	17

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PROFESSIONAL quality audio mixer. 6 channel, reverb. PA and recording use. Save 50 percent and more. Easy to build. $179.50. Free brochure. Neptune Electronics, 934 N.E. 25th, Portland, Oregon 97232.

FREE diodes and catalog! Also Photo Pin Detector Diodes HP5082-4203, $1.99. BDJ Electronics, 33 Howard, Orangeburg, New York 10962.

B&K TEST EQUIPMENT. 15% discount. Free shipping. Free Catalog. Spacetron, Box 84G, Broadview, IL 60153.

RECEIVERS, Transmitters, Components, Test Equipment. Catalog 25 cents. E. French, P.O. Box 249, Aurora, Ill. 60507.

250 PIECE assortment of hard to find nuts used in the electronics industry. Over 45 different sizes in brass, steel, aluminum. $4.75 postpaid. Fastening Products, Box 151A, Cheltenham, PA 19012.

HIGH FIDELITY

DIAMOND NEEDLES and Stereo Cartridges at Discount prices for Shure, Pickering, Stanton, Empire, Grado and ADC. Send for free catalog. LYLE CARTRIDGES, Dept. P, Box 69, Kensington Station, Brooklyn, New York 11218.

WANTED

GOLD, Silver, Platinum, Mercury wanted. Highest prices paid by refinery. Ores assayed. Free circular. Mercury Terminal, Norwood, MA 02062.

TAPE AND RECORDERS

RENT 4-Track open reel tapes—free brochure. Stereo-Parti, P.O. Box 7, Fulton, CA 95401.

1930-1962 Radio Programs. Reels, $1.00 Hour! Cassettes, $1.00 Show!. . .Mammoth Catalog, $1.25. AM Treasures, Box 192PE, Babylon, N.Y. 11702.

COLOR VIDEO TAPE RECORDER: $250; TV Camera: $150; VideoTapes: $5; Cartrivision tools, manuals, parts. Trimble, 5835 Herma, San Jose, CA 95123.

RECORDS—TAPES! Discounts to 73%; all labels; no purchase obligations; newsletter; discount dividend certificates; 100% guarantees. Free details. Discount Music Club, 650 Main St., Dept 5-86, New Rochelle, New York, N.Y. 10801.

NEW KITS

LOGIC PROBE KIT—Use with CMOS, TTL, DTL, RTL, HTL, HiNIL and most MOS IC's. Built-in protection against polarity reversal and overvoltage. Draws only a few mA from circuit under test. Dual LED readout. Complete kit includes case and clip leads. $8.95

VARIABLE REGULATED POWER SUPPLY KIT—Continuously variable from 3 to over 15 Volts. Short-circuit proof with electronic current limiting at 300 mA. Compact size and typical regulation of 0.1% make this a great bench or lab power supply. $11.95

FIXED REGULATED POWER SUPPLY KITS—Short-circuit proof with thermal current limiting. Compact size and typical regulation of 0.5% make these ideal for most electronic projects. Available for 5V @ 500mA, 6V @ 500mA, 9V @ 500mA, 12V @ 400mA, 15V @ 300mA. Specify voltage when ordering. $8.95 ea.

These easy-to-assemble kits include all components, complete detailed instructions and plated fiberglass PC boards. Power supply kits do not include case or meters. Add $1.25 per kit for postage and handling.

TRANSISTORS (NPN)	
2N918 TYPE RF Amp & Oscillator to 1 GHz	3/$1.00
2N3563 TYPE RF Amp & Osc to 1 GHz (pl. 2N918)	6/$1.00
2N3565 TYPE Gen. Purpose Gain (TO-92/106)	6/$1.00
2N3866 TYPE RF Power Amp 1.5 W @ 450 MHz	$0.75
2N3904 TYPE GP Amp & Sw to 100 mA hFE 100	6/$1.00
Assort. NPN GP TYPES, e.g. 2N3694, 2N3903, etc. (15)	$2.00
2N3638 TYPE (PNP) GP Amp & Sw to 300 mA	6/$1.00
2N3906 TYPE (PNP) GP Amp & Sw to 30 MHz	6/$1.00
FET's:	
N-CHANNEL (LOW-NOISE)	
2N4091 TYPE RF Amp & Switch (TO-18/106)	3/$1.00
2N4416 TYPE RF Amplifier to 450 MHz (TO-72)	2/$1.00
2N5163 TYPE Gen. Purpose Amp & Sw (TO-106)	3/$1.00
2N5486 TYPE RF Amp to 450 MHz (plastic 2N4416)	2/$1.00
E100 TYPE Low-Cost Audio Amplifier	4/$1.00
ITE4868 TYPE Ultra-Low Noise Audio Amp	2/$1.00
TIS74 TYPE High-Speed Switch 40Ω	3/$1.00
Assort. RF & GP FET's, e.g. 2N5163, MPF102, etc. (8)	$2.00
P-CHANNEL:	
2N4360 TYPE Gen. Purpose Amp & Sw (TO-106)	3/$1.00
E175 TYPE High-Speed Switch 125Ω (TO-106)	3/$1.00

SUPER SPECIALS:

2N2222 NPN TRANSISTOR GP Amp & Switch	6/$1.00
2N2907 PNP TRANSISTOR GP Amp & Switch	6/$1.00
2N3553 RF Power Amp 5 W @ 150 MHz, 7 W @ 50 MHz	$1.50
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556 DUAL 555 TIMER 1 μsec to 1 hour (DIP)	$0.90
723 VOLT. REGULATOR 3-30 V @ 1-200 mA (DIP/TO-5)	3/$1.00
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8038 WAVEFORM GENERATOR [illegible] Wave w/ckts	$4.50
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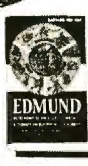

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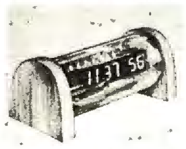

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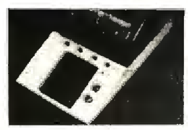

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711	DIP	.30
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4006A	1.55	4022A	1.10	4071A	.30
4007A	.30	4023A	.29	4072A	.40
4008A	1.79	4024A	1.02	4073A	.45
4009A	.66	4025A	.29	4075A	.45
4010A	.62	4027A	.68	4078A	.45
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4012A	.29	4030A	.51	4518A	1.89
4013A	.52	4035A	1.46	4528A	1.84
4014A	1.49	4040A	1.39	4585A	2.10
4015A	1.49	4042A	1.69	4901A	.45
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74C00	.25	74C74	1.20	74C162	2.93
74C02	.30	74C76	1.54	74C163	3.06
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74C08	.78	74C151	3.00	74C173	2.61
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MM5311	$4.45	MM5314	4.45
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14 pin	.22	28 pin	.59
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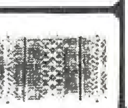

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LM311	Volt Comparator DIP, TO-5	10/	8.08	100/	71
LM340T	5V Regulator TO-220	10/	13.50	100/	119
75491	Quad Segment Driver DIP	10/	6.37	100/	56
7430	8 input gate DIP	10/	1.78	100/	16
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Temp. COEF • 50ppm C
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60 compartment storage cabinet — table or wall mount. Ready to use.

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PACKAGE OF 10 — DEDUCT 15%
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INCLUDES:
MM314 clock circuit
6 FND70 LED displays (.250" red 7 segment)
All necessary transistors, resistors & capacitors
1 double sided PC board accommodates LED's & clock circuitry
Schematic & instructions
Does not include 12V-300 ma transformer, switches & case **$12.95**

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1000 -		.10	.08

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23.7	78.7	187	1.15K	13.0K	45.3K
25.5	84.5	191	1.5 K	15.0K	48.7K
30.9	105	205	2.49K	18.2K	54.9K
34.8	110	232	3.57K	19.1K	60.4K
40.2	115	243	4.75K	19.6K	64.9K
45.3	137	499	5.49K	22.6K	69.8K
51.1	147	604	6.04K	24.9K	84.5K
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7404	.22	7464	.40	74157	1.14
7405	.22	7465	.40	74158	2.06
7406	.40	7470	.35	74160	1.60
7407	.40	7472	.35	74161	1.44
7408	.21	7473	.40	74162	1.71
7409	.22	7474	.40	74163	1.60
7410	.18	7475	.66	74164	1.83
7411	.29	7476	.45	74165	1.83
7413	.63	7483	.91	74166	1.71
7414	.81	7485	1.27	74170	2.65
7416	.40	7486	.46	74173	1.71
7417	.40	7489	2.48	74174	1.86
7420	.18	7490	.59	74175	1.60
7422	.30	7491	1.12	74176	1.02
7423	.33	7492	.82	74171	.97
7425	.31	7493	.69	74180	1.04
7426	.30	7494	1.08	74181	3.43
7427	.33	7495	.91	74182	.91
7430	.23	7496	.91	74184	2.29
7432	.26	74100	1.50	74185	2.29
7437	.40	74105	.51	74187	4.50
7438	.40	74107	.46	74190	1.35
7440	.20	74121	.48	74191	1.35
7441	1.13	74122	.52	74192	1.25
7442	.89	74123	.69	74193	1.19
7443	1.00	74125	.62	74194	1.25
7444	1.00	74126	.72	74195	1.02
7445	1.02	74132	1.02	74916	1.44
7446	1.07	74141	1.20	74197	1.02
7447	1.02	74145	1.20	74198	2.06
7448	1.20	74150	1.12	74199	2.06
7450	.20	74151	.91	74200	5.90
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74L03	.29	74L71	.29	74L93	1.94
74L04	.29	74L72	.45	74L95	1.94
74L06	.29	74L73	.56	74L98	3.21
74L10	.29	74L74	.56	74L164	3.21
74L20	.38	74L78	.91	74L165	3.21
74L30	.38	74L85	1.44		
74L42	1.71	74L86	.79		

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74LS02	.36	74LS40	.45	74LS107	.59
74LS04	.36	74LS42	1.40	74LS164	2.20
74LS08	.38	74LS74	.59	74LS193	2.20
74LS10	.36	74LS90	1.30	74LS197	2.20
74LS20	.36	74LS93	1.30		

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74H00	.25	74H22	.25	74H61	.25
74H01	.25	74H30	.25	74H62	.25
74H04	.25	74H40	.25	74H74	.39
74H08	.25	74H50	.25	74H101	.39
74H10	.25	74H52	.25	74H102	.49
74H11	.25	74H53	.25	74H103	.58
74H20	.25	74H55	.25	74H106	.58
74H21	.25	74H60	.25	74H108	.60

SCHOTTKY

74S00	.38	74S08	.52	74S22	.38
74S02	.45	74S10	.38	74S32	.52
74S03	.38	74S20	.38	74S74	.38
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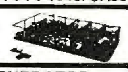

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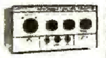

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7401N	.18	.16	7453N	.14	.13	74153N	.85	.75
7402N	.18	.16	7454N	.14	.13	74154N	1.08	.94
7403N	.18	.16	7460N	.14	.13	74156N	1.02	.92
7404N	.21	.19	7470N	.40	.30	74156N	1.02	.92
7405N	.20	.19	7472N	.40	.30	74157N	.90	.80
7406N	.36	.28	7473N	.42	.38	74158N	1.50	1.30
7407N	.36	.28	7474N	.44	.40	74160N	1.02	.92
7408N	.24	.21	7475N	.55	.50	74161N	1.10	1.00
7409N	.28	.21	7476N	.44	.40	74162N	1.40	1.30
7410N	.22	.19	7483N	.82	.76	74163N	1.00	.90
7411N	.26	.20	7484N	1.80	1.70	74164N	1.16	1.05
7412N	.34	.32	7485N	1.20	1.08	74165N	1.20	1.10
7413N	.45	.42	7486N	.44	.40	74166N	1.20	1.10
7414N	.98	.95	7489N	2.20	2.10	74170N	2.00	1.80
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7417N	.35	.32	7492N	.56	.50	74174N	1.00	.90
7420N	.15	.14	7493N	.62	.56	74175N	.96	.90
7421N	.30	.26	7494N	.88	.80	74176N	1.08	1.00
7422N	.50	.45	7495N	.80	.72	74177N	1.08	1.00
7423N	.37	.36	7496N	.75	.68	74179N	1.80	1.70
7425N	.30	.23	7497N	5.00	4.50	74180N	1.12	1.02
7426N	.28	.26	74100N	1.10	1.00	74181N	3.00	2.70
7427N	.28	.25	74107N	.40	.36	74182N	1.00	.90
7430N	.26	.20	74109N	.40	.36	74184N	2.80	2.50
7432N	.32	.30	74111N	1.00	.90	74185N	3.00	2.70
7437N	.29	.20	74116N	2.00	1.80	74188N	5.00	4.80
7438N	.29	.27	74121N	.60	.54	74190N	1.20	1.10
7439N	.44	.40	74122N	.48	.43	74191N	1.20	1.10
7440N	.17	.16	74123N	.68	.62	74192N	.98	.90
7441N	.85	.83	74125N	.50	.45	74193N	.92	.88
7442N	.40	.39	74126N	.50	.45	74194N	1.36	1.23
7445N	.90	.81	74128N	.50	.45	74195N	.75	.70
7446N	.90	.81	74132N	.92	.85	74196N	1.40	1.30
7447N	.98	.90	74141N	1.70	1.50	74197N	1.40	1.30
7448N	.98	.90	74145N	1.10	1.00	74198N	1.40	1.30
7450N	.14	.13	74147N	1.90	1.70	74199N	1.40	1.30
			74148N	1.50	1.35	74221N	1.36	1.25
			74150N	1.52	1.40	74279N	.65	.60

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74H04N	.33	74H10N	.33	74H74N	.80		

74LS00

74LS00N	.36	74LS32N	.45	74LS112N	.58	74LS174N	2.20
74LS02N	.36	74LS51N	.39	74LS114N	.92	74LS175N	2.40
74LS04N	.44	74LS54N	.58	74LS138N	1.89	74LS181N	3.69
74LS05N	.44	74LS73N	.58	74LS139N	2.00	74LS190N	2.85
74LS08N	.38	74LS74N	.56	74LS151N	1.68	74LS191N	2.85
74LS10N	.36	74LS76N	.65	74LS153N	1.80	74LS193N	2.50
74LS20N	.44	74LS107N	.59	74LS160N	3.00	74LS260AJ	.44
74LS30N	.39	74LS109N	.92	74LS161N	3.00		

SCHOTTKY TTL

74S00	.44	74S11	.65	74S64	.80	74S114	1.20
74S02	.60	74S20	.65	74S74	.90	74S133	.80
74S04	.55	74S30	.80	74S76	1.16	74S138	2.20
74S08	.80	74S32	.80	74S112	1.00	74S151	2.20
74S10	.55	74S40	.65	74S113	1.50	74S160	3.90
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LM301AN	1.10	LM312H	1.75	LM340-18K	2.60	LM733CD	3.50
LM304H	1.20	LM318H	1.50	LM340-24K	2.60	LM733CN	1.30
LM305H	.85	LM318M	2.40	LM555CM	.70	LM741CH	.40
LM305AH	1.05	LM324N	1.90	LM556CN	1.30	LM741CD	1.25
LM305N	1.00	LM331N	1.25	LM567CM	1.70	LM741CM	.39
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LM308H	.85	LM320-5K	2.90	LM709CN	.75	LM747CN	.90
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LM308M	1.00	LM320-12K	2.90	LM710CN	.90	LM3046CN	.95
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4001AE	.24	.20	4033AE	2.00	1.90	4075AE	.40	.39
4002AE	.24	.15	4035AE	1.20	1.10	4076AE	1.24	1.22
4006AE	1.30	1.20	4040AE	1.20	1.10	4077AE	.40	.39
4007AE	.24	.23	4041AE	1.25	1.00	4078AE	.40	.39
4008AE	1.15	1.14	4042AE	1.00	.85	4081BE	.40	.39
4009AE	.50	.45	4043AE	.95	.90	4082AE	.39	.38
4010AE	.50	.45	4044AE	.95	.90	4093AE	1.65	1.64
4011AE	.24	.23	4046AE	3.10	3.05	4095BE	1.95	1.94
4012AE	.24	.22	4047AE	2.00	1.90	4098AE	1.30	1.29
4013AE	.30	.28	4048AE	1.43	1.40	4099AE	2.90	2.89
4014AE	1.05	1.00	4049AE	.58	.53	4502AE	1.50	1.49
4015AE	1.15	1.10	4050AE	.58	.53	4507BE	.60	.55
4016AE	.55	.49	4051AE	1.49	1.48	4508BE	2.20	2.19
4017AE	1.05	1.00	4052AE	1.40	1.39	4510AE	1.40	1.39
4018AE	1.24	1.23	4053AE	1.40	1.39	4511BE	2.00	1.99
4019AE	.54	.49	4055AE	1.95	1.94	4512BE	1.30	1.29
4020AE	1.45	1.35	4056AE	1.99	1.98	4514AE	5.00	4.99
4021AE	1.30	1.20	4060AE	1.70	1.68	4515AE	5.00	4.99
4022AE	1.05	1.00	4063AE	2.50	2.49	4516AE	1.75	1.74
4023AE	.24	.22	4066AE	.90	.89	4518AE	1.28	.98
4024AE	.80	.70	4068AE	.44	.43	4520AE	1.28	.98
4025AE	.24	.20	4069AE	.44	.43	4528AE	2.20	2.19
4026AE	1.50	1.49	4070BE	.60	.59	4585AE	2.05	1.96
4027AE	.55	.50	4071AE	.45	.44	4901AE	.32	.31
4028AE	.95	.90	4072AE	.34	.33	4911AE	.32	.31
4029AE	1.20	1.10						

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WIRING PEN — The wiring pen with self-contained spool of polyurthane lacquer insulated copper wire is used to route and wrap onto component leads, terminal pin, etc. Connections are completed by soldering which melts insulation & at the same time makes permanent solder joint.

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LEDs

.125" dia.			.160" dia.			.200" dia.		
209	RED	$.25	215	RED	$.25	220	RED	$.25
209	YELLOW	.35	215	YELLOW	.30	220	YELLOW	.30
209	GREEN	.35	216	GREEN	.30	220	GREEN	.30

LOW PROFILE

.200" dia.			.200" dia.					
226	RED	$.25	5053	RED	$.35	MV50	RED	$.30
226	YELLOW	.30	5053	YELLOW	.40			
226	GREEN	.30	5053	GREEN	.40			
226	ORANGE	.30	5053	ORANGE	.40			

216 = MV5024
5053 = MV5053

MATSUO
DIPPED TANTALUM CAPACITORS

MFD	WVDC	1-9	10up	50up	MFD	WVDC	1-9	10up	50up
.1	35	$.30	$.25	$.20					
.15	35	.30	.25	.20	4.7	35	$.40	$.32	$.26
.22	35	.30	.25	.20	6.8	35	.40	.32	.26
.33	35	.30	.25	.20	10.0	16	.38	.30	.24
.47	35	.30	.25	.20	10.0	25	.39	:31	.25
.68	35	.30	.26	.20	10.0	35	.40	.32	.26
1.0	35	.30	.25	.20	15.0	35	.95	.64	.56
1.5	35	.35	.28	.23	22.0	16	.40	.32	.26
2.2	20	.30	.25	.20	33.0	20	.96	.64	.56
2.2	35	.35	.28	.23	47.0	20	1.40	1.05	.90
3.3	35	.38	.30	.24	68.0	16	1.40	1.05	.90

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IN5249B	19	.22
IN5250B	20	.22
IN5251B	22	.22
IN5252B	24	.22
IN5253B	25	.22
IN5254B	27	.22
IN5255B	28	.22
IN5256B	30	.22
IN5257B	33	.22
IN5258B	36	.22
IN5259B	39	.22
IN5260B	43	.22
IN5261B	47	.22
IN5262B	51	.22
IN5263B	56	.22
IN5264B	60	.22
IN5265B	62	.22
IN5266B	68	.22
IN5267B	75	.22
IN5223B	2.7	.22
IN5224B	2.8	.22
IN5225B	3.0	.22
IN5226B	3.3	.22
IN5227B	3.6	.22
IN5228B	3.9	.22
IN5229B	4.3	.22
IN5230B	4.7	.22
IN5231B	5.1	.22
IN5232B	5.6	.22
IN5233B	6.0	.22
IN5234B	6.2	.22
IN5235B	6.8	.22
IN5236B	7.5	.22
IN5237B	8.2	.22
IN5238B	8.7	.22
IN5239B	9.1	.22
IN5240B	10	.22
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Build & test circuits as fast as you think!

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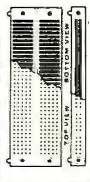

Plug-in, wire, test, modify or expand without patch cords or solder. Snap together to form breadboard needed.

PN/Description	L.	Hole-to-Hole	Term'ls	Price
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QT47B Bus	5.3"	5.0"	16	2.25
QT35S Socket	4.1"	3.8"	70	8.50
QT35B Bus	4.1"	3.8"	12	2.00
QT18S Socket	2.4"	2.1"	36	4.75
QT12S Socket	1.8"	1.5"	24	3.75
QT8S Socket	1.4"	1.1"	16	3.25
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16	.54	.49	.44

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14	.34	.31	.28
16	.37	.34	.31

SOLDER-TIN DIP

	1-24	25	100
8	.21	.19	.17
14	.25	.22	.20
16	.28	.25	.23
18	.34	.31	.28
22	.37	.36	.35
24	.47	.43	.40
28	.88	.80	.70
36	1.09	.98	.89
40	1.24	1.12	.90

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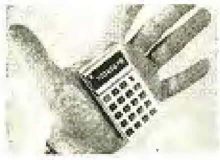

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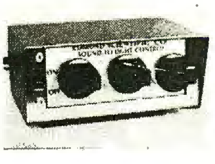

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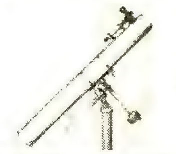

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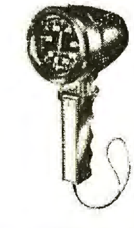

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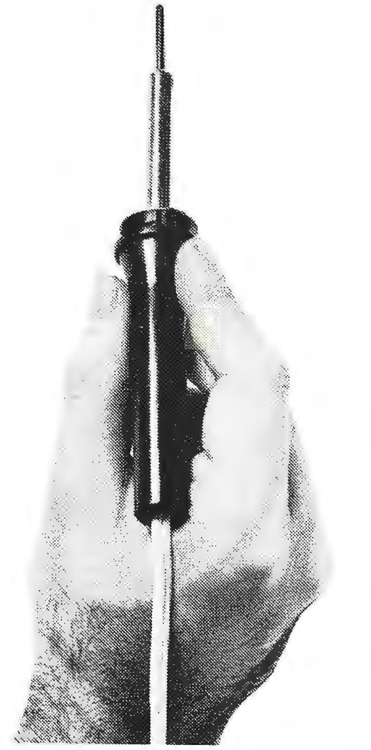

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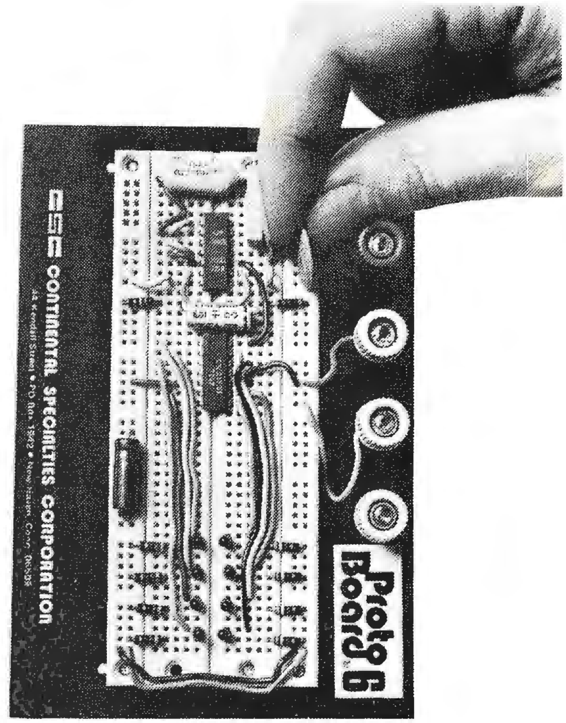

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